Aalto University
School of Business

IPO Underpricing and Long-term Performance in the US Stock Market

Evidence from the New York and Nasdaq Stock Exchanges

Master's Thesis
Niklas Lahti
Aalto University School of Business
Master's Programme in Finance
Spring 2021

Aalto University
School of Business

Aalto University, P.O. BOX 11000, 00076 AALTO
www.aalto.fi

Abstract of master's thesis

Author	Niklas Lahti
Title of thesis	IPO Underpricing and Long-term Performance in the US Stock Market
Degree	Master of Science in Economics and Business Administration
Degree programme	Finance
Thesis advisor(s)	Matti Suominen
Year of approval	2021
Number of pages	64
Language	English

Abstract

The purpose of this paper is to examine the phenomena of IPO underpricing and long-term underperformance on the NYSE and Nasdaq stock exchange between 2003-2019. Hence, the study focuses on the post-tech bubble era, and further compares the periods before, during, and after the global financial crisis. These two well-known anomalies have been widely documented, yet companies listed on the US market in the 21st century have received little attention.

The study reveals a positive initial market-adjusted return of 14.8% for the data, but cannot find any statistically significant under or overperformance over the first three years of trading, when initial returns are excluded. The level of underpricing of the 1811 IPOs also remains relatively stable throughout the sample period, although some significant growth can be observed since 2017, when average initial returns began to rise to new highs, thus raising a question of a potential stock market bubble. IPOs that were executed during the financial crisis, instead, show no evidence of higher first-day trading returns with mean underpricing level of 12.4%. These results of IPO underpricing are consistent with previous literature, but the changing market environment should be taken into account when drawing conclusions, as high-technology and venture-capital backed companies, namely startups, embody continuously larger shares of all IPOs.

Long-term performance is studied with two common methodologies, cumulative abnormal return (CAR) and buy-and-hold abnormal return (BHAR). In addition, both equally-weighted and value-weighted portfolios are constructed for robustness purposes. Nonetheless, the 1461 IPOs in 2003-2016 show no evidence of underperformance, and companies listed in 2007-2009 even outperformed the market index, S&P 500. These results strongly conflict with previous literature, where the long-term underperformance is widely accepted as a persistent anomaly in IPO markets. However, the phenomenon appears to be disappearing from the US stock markets, yet further research is needed to find the causes.

Keywords Initial public offering, IPO, underpricing, initial return, long-term performance

Aalto-yliopisto
Kauppakorkeakoulu

Aalto-yliopisto, PL 11000, 00076 AALTO
www.aalto.fi

Maisterintutkinnon tutkielman tiivistelmä

Tekijä Niklas Lahti

Työn nimi Listautumisantien alihinnoittelu ja pitkän aikavälin suoriutuminen Yhdysvaltojen arvopaperimarkkinoilla

Tutkinto Kauppatieteiden maisteri, KTM

Koulutusohjelma Rahoitus

Työn ohjaaja(t) Matti Suominen

Hyväksymisvuosi 2021 **Sivumäärä** 64 **Kieli** Englanti

Tiivistelmä

Tämän tutkimuksen tarkoituksena on tarkastella lyhyen aikavälin alihinnoittelun ja pitkän aikavälin alisuoriutumisen ilmiöitä NYSE ja Nasdaq pörsseissä vuosien 2003-2019 välillä. Tutkimus keskittyy siis teknologiakuplan jälkeiseen aikaan, ja vertailee lisäksi ajanjaksoja ennen globaalia finanssikriisiä, sen aikana ja sen jälkeen. Nämä kaksi hyvin tunnettua anomaliaa on dokumentoitu laajalti, mutta 2000-luvulla USA:n markkinoille listautuneet yritykset ovat saaneet osakseen vain vähän huomiota.

Tutkimus osoittaa datalle positiivisen 14.8% markkinakorjatun alkutuoton, muttei löydä tilastollisesti merkitsevää ali- tai ylisuoriutumista kolmen ensimmäisen kaupankäyntivuoden aikana, kun alkutuotot jätetään pois. 1811 pörssilistautumisen alihinnoittelun taso säilyy myös suhteellisen vakaana koko otosjakson ajan, joskin merkittävää kasvua voidaan havaita vuodesta 2017 alkaen, jolloin keskimääräiset alkutuotot alkoivat nousta uusiin korkeuksiin, jättäen näin ilmoille kysymyksen mahdollisesta osakemarkkinakuplasta. Finanssikriisin aikana toteutetut listautumisannit eivät sen sijaan osoita mitään todisteita korkeammista ensimmäisen kaupankäyntipäivän tuotoista keskimääräisellä 12.4% alihinnoittelutasollaan. Nämä listautumisantien alihinnoittelun tulokset ovat johdonmukaisia aikaisemman kirjallisuuden kanssa, mutta muuttuva markkinaympäristö tulisi ottaa huomioon johtopäätöksiä tehdessä, kun korkean teknologian ja venture capital-tuetut yritykset, nimittäin startupit, edustavat jatkuvasti suurempaa osuutta kaikista pörssilistautumisista.

Pitkän aikavälin tuottoa tutkitaan kahdella yleisellä menetelmällä, kumulatiivisella abnormaalilla tuotolla (CAR) ja osta-ja-pidä abnormaalilla tuotolla (BHAR). Lisäksi sekä tasapainotetut että arvopainotetut portfoliot on rakennettu tuloksien luotettavuuden tarkistamiseksi. Yhtä kaikki, 1461 listautumisantia vuosien 2003-2016 aikana ei osoita minkäänlaista näyttöä alisuoriutumisesta, ja vuosien 2007-2009 aikana listautuneet yritykset jopa suoriutuvat paremmin kuin markkinaindeksi S&P 500. Nämä tulokset ovat vahvasti ristiriidassa aiemman kirjallisuuden kanssa, jossa pitkän aikavälin alisuoriutuminen on laajasti hyväksytty jatkuvana poikkeamana IPO-markkinoilla. Ilmiö vaikuttaa kuitenkin olevan katoamassa Yhdysvaltojen osakemarkkinoilta, mutta vaatii vielä lisätutkimuksia syiden löytämiseksi.

Avainsanat Listautumisanti, IPO, alihinnoittelu, alkutuotto, pitkän aikavälin suoriutuminen

Table of contents

List of tables 2

List of figures 3

1. Introduction 1

2. Literature review 4
   2.1 IPO underpricing 4
      2.1.1 Winner's curse 6
      2.1.2 Signalling and Market-feedback 7
      2.1.3 Behavioral theories 9
   2.2 Long-term underperformance 10
      2.2.1 Fads, overoptimism, and the window of opportunity 10
      2.2.2 Choice of methodology and benchmark 11

3. Data and methods 13
   3.1 Data Collection 13
   3.2 Description of the sample 14
      3.2.1 Division between NYSE and Nasdaq stock exchange 14
      3.2.2 Industry classification 15
      3.2.3 VC-backed, PE-backed, and high-technology companies 16
      3.2.4 Long-term performance sample 19
   3.3 Methodology 21
      3.3.1 IPO Underpricing 21
      3.3.2 Long-term performance 22
      3.3.3 Multivariate OLS regression 25

4. Findings 27
   4.1 Underpricing 27
      4.1.1 Total sample statistics 27
      4.1.2 Initial return of the high-tech, VC-backed, and PE-backed IPOs 30
      4.1.3 Initial returns by the stock exchange 32
      4.1.4 Initial returns by the industry 33
      4.1.5 Multivariate regression analysis of initial returns 35
   4.2 Long-term Performance 40
      4.2.1 Cumulative Abnormal Returns 40
      4.2.2 Buy-and-Hold Abnormal Returns 47

5. Discussion 50
   5.1 Underpricing 50
   5.2 Long-term performance 52

6. Conclusions 54

7. References 55

List of appendices 60

List of tables

Table 1: International studies of the IPO initial returns and long-term performance 2

Table 2: IPOs categorized by the stock exchange, total sample 15

Table 3: IPOs categorized by the industry, total sample..... 16

Table 4: Share of VC-backed, PE-backed, and high-tech IPOs, total sample 17

Table 5: Share of VC-backed, PE-backed and high-tech IPOs on the NYSE, total sample 18

Table 6: Share of VC-backed, PE-backed and high-tech IPOs on the Nasdaq, total sample .. 19

Table 7: IPOs categorized by the stock exchange, long-term performance study 20

Table 8: List of explanatory variables in the study of IPO underpricing..... 26

Table 9: IPO statistics of initial returns, proceeds, and total assets 27

Table 10: Initial returns categorized by high-tech, VC-backed, and PE-backed IPOs 31

Table 11: Initial returns categorized by the industry..... 34

Table 12: OLS regressions categorized by the issue period..... 37

Table 13: OLS regressions categorized by the industry..... 39

Table 14: Abnormal Returns for Initial Public Offerings in 2003 – 2016 42

List of figures

Figure 1: Mean First-Day Returns and Money Left on Table, 2003-2019 28

Figure 2: Number of IPOs and Mean First-Day Returns, 2003-2019 29

Figure 3: Number of IPOs and initial returns on the NYSE and Nasdaq stock exchange 32

Figure 4: Mean Cumulative Raw and Market-adjusted Returns in 2003 – 2016 41

Figure 5: Mean Cumulative Raw and Market-adjusted Returns in 2003 – 2006 43

Figure 6: Mean Cumulative Raw and Market-adjusted Returns in 2007 – 2009 45

Figure 7: Mean Cumulative Raw and Market-adjusted Returns in 2010 – 2016 46

Figure 8: Equal-weighted Buy-and-hold Returns in 2003 – 2016 48

Figure 9: Value-weighted Buy-and-hold Returns in 2003 – 2016 49

1. Introduction

This paper explores the puzzle of short-term underpricing and long-term underperformance in New York and Nasdaq stock exchanges between 2003 and 2019. The underpricing and underperformance of initial public offerings are two well-known and persistent anomalies in the global financial markets. The phenomena are well studied and researchers like Aggarwal and Rivoli (1990), Ritter (1991), Keloharju (1993), Mitchell and Stafford (2000), Schultz (2003), and Jewartowski and Lizińska (2012) argue that companies tend to experience significant initial returns over the first day of trading but underperform the market over a three-to-five-year period following the offering date when the initial returns are excluded, regardless of the market benchmark employed. Recently, however, the long-term underperformance of initial public offerings has been challenged, and Loughran and Ritter (2004) demonstrate that also the underpricing vary across time and environment, making the average size of initial returns rather cyclical. Table 1 summarizes some of the most impactful studies in examining the first day returns and the long-term performance of initial public offerings in international stock markets.

Technological and regulative developments in the 21st century have brought both transparency and liquidity to the initial public offerings, and hence question some of the determinants that justify the level of underpricing and underperformance in previous literature. Additionally, earlier papers investigating the underpricing and underperformance phenomena concentrate on IPOs that took place prior the tech bubble, whereas later studies focus on smaller and developing markets. Hence, it is of interest to study the more recent Western IPOs and examine if changes in the macro and microeconomic environments have affected the significance or direction of the two anomalies in the most developed stock markets in the world, namely NYSE and Nasdaq stock exchange.

Table 1: International studies of the IPO initial returns and long-term performance

Below are listed some of the most relevant studies of the IPO underpricing and long-term performance in global stock markets. Irrespective of the market, approach, or time period examined, the short-term returns have been positive and statistically significant, while in the long run IPOs yield lower returns on average than the benchmark portfolio studied. First day returns were not disclosed in all the papers, although the methodologies to calculate initial returns and long-term performance are similar.

Author(s)	Market	Sample Size	Period	Approach	Initial Returns	Long-run performance
Lee et al. (1996)	Australia	N = 266	1976 – 1989	CAR	16.4 %	-46.5 %
Kooli and Suret (2004)	Canada	N = 445	1991 – 1998	BHAR	20.6 %	-16.9 %
Chi and Padgett (2010)	China	N = 897	1996 – 2002	BHAR	131.7 %	16.6 %
Su et al. (2011)	China	N = 936	1996 – 2005	BHAR	-	8.6 %
Keloharju (1993)	Finland	N = 80	1984 – 1989	CAR	8.7 %	-21.1 %
Boissin and Sentis (2014)	France	N = 207	1991 – 2005	BHAR	11.1 %	-28.9 %
Ljungqvist (1997)	Germany	N = 154	1970 – 1990	CAR	9.2 %	-12.1 %
Bessler and Thies (2007)	Germany	N = 218	1977 – 1995	BHAR	-	-12.7 %
Arosio et al. (2001)	Italy	N = 150	1985 – 1996	BHAR	24.8 %	-23.0 %
Kirkulak (2008)	Japan	N = 433	1998 – 2001	CAR	49.9 %	-18.3 %
Jewartowski and Lizińska (2012)	Poland	N = 186	1998 – 2008	BHAR	14.0 %	-22.6 %
Alli et al. (2010)	South Africa	N = 141	1995 – 2004	BHAR	7.4 %	1.1 %
Alvarez and Gonzales (2005)	Spain	N = 52	1987 – 1997	BHAR	13.0 %	-18.6 %
Loughran et al. (1994)	Sweden	N = 162	1980 – 1990	CAR	38.2 %	1.2 %
Drobetz et al. (2005)	Switzerland	N = 109	1983 – 2000	BHAR	35.0 %	-1.7 %
Brown (1999)	UK	N = 232	1990 – 1995	BHAR	8.7 %	-0.9 %
Gregory et al. (2010)	UK	N = 2499	1974 – 2004	BHAR	-	-16.4 %
Ritter (1991)	US	N = 1526	1974 – 1984	CAR	14.3 %	-29.1 %
Loughran and Ritter (1995)	US	N = 4753	1970 – 1990	BHAR	-	-26.9 %
Ritter and Welch (2002)	US	N = 6249	1980 – 2001	BHAR	18.8 %	-23.4 %
Median		**N = 225**			**15.4 %**	**-17.6 %**

Literature review in section two sheds some light on the theoretical background of IPO underpricing and long-term underperformance and further provides multiple explanations on why the stock prices increase significantly over the first day of trading yet yield lower returns in the long-run than the market in general. This study, however, does not attempt to develop a new theory to explain the market inefficiencies or take a position on it if behavioral theories would better explain the behavior of stock prices rather than the traditional theories. Instead, since only a few relevant articles have been published in recent years, the aim is to investigate whether the two anomalies still exist in the US market now that knowledge has become the highest value in society and all information is available.

The rest of the paper is organized as follows. In section 2, I discuss the previous literature on IPO underpricing and long-run underperformance. Data and methodology are described in section 3, followed by findings in section 4. I then discuss the results in section 5 and conclude the study in section 6.

2. Literature review

2.1 IPO underpricing

There are several reasons why small and large companies around the world go public and list their shares on a stock exchange. Going public refers to a private company's initial public offering (IPO), where they raise capital for growth and become a publicly traded and owned business. Even if listing a company entails major responsibilities, like regular audit and financial reporting, and is not a cheap process to push through, the upsides often outweigh the disadvantages. Companies do not only raise a big amount of cash in a relatively short time and enable founders and other shareholders to convert some of their wealth into cash, but increase their publicity by getting notable media coverage, attract top-level executives, and have more influence in negotiating with vendors and distributors. However, companies often leave money on the table when going public by offering shares at a discount and rewarding initial investors with positive financial returns at the first day of trading. This well-known phenomenon is known as IPO underpricing.

IPO underpricing is the practice in listing a company to a stock market at a price below its real market value. The phenomenon has been extensively studied in empirical research providing evidence that the underpricing is a persistent event in the global IPO market, irrespective of the time period and geographical market studied. Underpricing is typically explained by asymmetric information, mainly winner's curse and signaling theories between the company, the market, and the underwriter, but is also argued to be a result of behavioral theories. Lowry et al. (2017) explain that each party has a certain informational advantage in a new offering, but at the same time lacks some of the other critical information. Management of the company has the most detailed information of the issuing firm, but in contrast, market participants have a better understanding about the aggregate demand for company shares. Also, since companies running an IPO tend to rely on services of an underwriter, and consequently, give them a lot of power in share allocation and price setting, the underwriter's incentives can be questioned.

Ibbotson (1975) is one of the first and most popular researchers to examine the underpricing phenomenon in a longer time frame with the motivation to consider it rather as a persistent than an occasional event. He studied the hypothesis with newly issued common stocks in the US from January 1960 to December 1969 and experienced an average initial return of 11.4%.

However, Ibbotson's data consists of offer prices and calendar month-end prices of corresponding stocks, making measuring impure since it includes up to one month's after-market performance. Additionally, his residuals do not follow normal distribution but are rather highly peaked and skewed to the right. This calls into question the reliability of his t-values, although Ibbotson later simulated the short-term performance estimates by drawing from the observed residuals and concluded them to closely resemble normal distribution. In spite of all, Ibbotson's results indicate positive initial returns, although no adequate explanation for the underpricing is given, and the hypothesis that investors have an equal chance for experiencing initial profit or loss could not be rejected. Based on the skewness of the results, however, likelihood for remarkably large positive initial returns is far higher than correspondingly large negative returns.

After Ibbotson's IPO research in the 1970s, numerous studies have been carried to evaluate initial public offerings and the underpricing phenomenon. Ritter (1984) introduces convincing evidence of IPO underpricing in 1977 – 1982, when he examines the difference of initial returns between the hot and cold issue markets in the United States. The 15-month "hot issue" period starting in January 1980 provided an average initial return of 48.4%, whereas the mean return in "cold issue" market was significantly less, 16.3%. Ritter calculates the underpricing percentage as the difference between issue price and the first day closing price, becoming a principle in later research, but does not adjust his results with the corresponding market movements. As a result, this may significantly affect the magnitude of underpricing, and therefore decrease the reliability of drawn conclusions. Ritter's motivation for the paper was generated by Ibbotson and Jaffe (1975), the first academic paper to study the "hot issue" phenomenon. These hot equity issues are periods when the aftermarket performance is abnormally high due to the excessive optimism of investors. Even if both Ritter (1984) and Ibbotson and Jaffe (1975) observed positive initial returns with their dataset, the papers focused primarily on the "hot issue" market and the discussion of occasional differences in the magnitude of underpricing rather than the underpricing anomaly itself.

One of the first papers to analyze and discuss the puzzle behind underpricing is from Beatty and Ritter (1986), where they demonstrate a relationship between the expected initial returns and the uncertainty of investors on firm values. They also show empirical evidence of underpricing equilibrium being enforced by the investment banking industry as underwriters are involved in multiple initial public offerings over time and cannot fool investors by

underpricing persistently too much or too little without getting penalized by the marketplace. As a conclusion, Beatty and Ritter (1986) argue that offerings which are deeply underpriced are also more often oversubscribed, thus creating a winner's curse for investors who place purchase orders on all issues. This is because they will be less often allocated with shares that increase in price than those which decline. For these reasons offerings must be underpriced on average, and the more ex ante uncertainty involved in the value per share, the greater the (expected) underpricing due to the intensifying winner's curse.

2.1.1 Winner's curse

Winner's curse is the tendency to overbid an item in an auction in order to win it, but with the cost of exceeding the intrinsic value. This phenomenon is often brought up as a potential explanation for the persistent underpricing anomaly in research, like Rock (1986), and Beatty and Ritter (1986), and is not experienced being in contradiction to other argumentations. However, winner's curse problem rests on simple and somewhat intuitive observations, which give grounds for skepticism.

Rock (1986) presents a model for the underpricing as a natural consequence of incorporating asymmetric information and rationing. He shows that to get uninformed investors participate in the IPO market, shares must be offered at a discount. Otherwise, informed investors would crowd out other investors when profitable issues are offered and leave valueless flotations for the uninformed investors who subscribe to every IPO, and as a result, drive them away of all new issues in the long run. This creates a winner's curse for the uninformed investors, and since the number of informed investors is limited, underwriters must give incentives for the uninformed to participate by underpricing new offerings on average. Even if this study from Rock (1986) is one of the most cited paper in the underpricing related research, it has experienced some well-founded debate. If, as Rock argues, resources of informed investors are limited, why would not the uninformed investors invest through investment funds (informed investors) in exchange for a fee, to avoid subscribing in overpriced issues and consequently enjoy the benefits of economies of scale and become informed.

Ibbotson et al. (1994) note that in general, different theories explaining IPO underpricing are not mutually exclusive and that a given explanation might be more important for some IPOs than the others. Numerous studies test the winner's curse model as an explanation for the initial

returns both in the US and other countries, and after finding positive relation between uncertainty and underpricing claim that the riskier the issue the greater the underpricing on average. Even if there is evidence in supporting this prediction, other theories explaining the phenomenon make the same prediction. Hence, winner's curse admittedly accounts for the underpricing but hardly explains it alone.

Examination of the winner's curse model requires proxies to explain the uncertainty and can be divided into three different groups: company characteristics, market characteristics, and issue characteristics. Typical company characteristics are market capitalization, log sales, age, and industry (Habib & Ljungqvist, 2001; Chan et al., 2004), since younger and smaller companies are experienced riskier, and thus involve more uncertainty. Also, high technology industries face higher uncertainty due to their typical fluctuations in growth and profits. Common market characteristics include trading volume and volatility, the same Ritter (1984) used in his study of the hot market issue. Both are common risk factors in the financial literature, and thus natural proxies to control ex-ante uncertainty in IPO underpricing. Finally, dominant issue characteristics consist of gross proceeds, venture capital (VC) and private equity (PE) backed offerings (dummy variables), and underwriter related qualities (Chemmanur, 1993; Lowry & Shu, 2002). These factors are frequently used as a proxy for uncertainty, and multiple studies have found a significant relationship between them and the underpricing. Ibbotson (1975) and Tinic (1988) hypothesize underwriters use underpricing as an insurance against litigation by lowering the probability and number of damages in the event of a lawsuit. Drake and Vetsuypens (1993), on the other hand, find evidence that initial returns of the sued firms are greater than those of the non-sued IPO companies, and, sued companies have significantly higher ranked underwriters to back them up in case of a lawsuit. Then, Keloharju (1993) studies IPOs in Finland, where there is negligible litigation risk associated with offerings, and finds an initial return of 8.7%, suggesting that expected litigation costs cannot explain the underpricing alone. Keloharju, however, notes that initial returns in the US are much higher than in Finland, and the litigation risk could possibly explain the difference.

2.1.2 Signalling and Market-feedback

One of the main reasons to go public is to address the quality of the company to the market. Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989) posit that high-class companies underprice their IPOs to signal their quality to the outside investors and to

enable larger issues in the future with more favorable terms, and hence recover the costs of IPO underpricing. Welch (1989) predicts companies that underprice their initial public offerings are more likely to perform a seasoned equity offering (SEO) in the future and execute it earlier after the IPO as well as in a larger scale. This argument comes with an underlying assumption that issuing firms have superior information to outside investors, but early empirical evidence provides little support to this claim. Jegadeesh et al. (1993), and Michaely and Shaw (1994) argue SEO activity has higher correlation with the aftermarket performance than the initial returns, and thus underpricing is unlikely acting as a communication tool from issuers to the investors. Jegadeesh et al. (1993) find, however, a positive relationship between the degree of underpricing and probability and size of the SEO, suggesting signaling theory explains some of the underpricing, but the economic significance is weak. However, another hypothesis that has a stronger explanatory power, known as "market-feedback hypothesis", is offered as an alternative. Consistently, Su (2004) investigates the signalling model in the Chinese market between 1994 and 1999 and shows a stronger correlation in the market-feedback hypothesis than the signalling hypothesis. Nevertheless, underpricing can be explained, to some extent, as a strategy to signal company value to investors. Michaely and Shaw (1994), instead, cannot find any evidence to support the argument of signalling and reject the hypothesis entirely. Their evidence is, however, consistent with the winner's curse hypothesis.

Francis et al. (2010) note that not all high-quality companies are willing to apply the signalling strategy when raising capital. Also, the firms who use signalling strategy are often subject to certain conditions, such as the need to raise external funds in the future, and thus reduce the total cost of capital raised. This strategy is in line with Ibbotson's (1975) suggestion that IPOs need to be underpriced to leave a "good taste in investors' mouths" and hence enable more attractive terms and prices in the future offerings. Francis et al. (2010) revisit the signalling hypothesis by studying foreign company IPOs in the US market from 1985 to 2000 which, in general, face higher information asymmetries. Consequently, foreign companies are subject to higher costs to make themselves known within the US investor community, and all else equal, more prone to use signalling strategy in their initial public offerings. Francis et al. (2010) find consistent results with Welch (1989) that higher level of underpricing significantly correlates with both the probability of a SEO, and earlier and larger SEO. In addition, stock price decreases less when the SEO is announced.

While empirical evidence of the signalling hypothesis is mixed, Brämisch et al. (2011) note the literature either proves underpricing has a low explanatory power as a signalling mechanism or has focused too narrowly on firm-specific dependent variables. Empirical studies predominantly focus on internal performance characteristics implying the primary determinant in company performance is the firm's internal environment instead of industry-related factors. However, firms that run an IPO are generally too young and small to achieve a competitive advantage through strategic management, suggesting signalling mechanisms might reveal more information about the quality of the industry than the firm-specific performance. In support to this argument, Brämisch et al. (2011) study European property company (EPC) IPOs between 1997 and 2007 and show the degree of underpricing significantly signals information about the prospect of the underlying industry.

2.1.3 Behavioral theories

In the literature, underpricing is often explained by asymmetric information-based theories. However, Ljunqvist (2005) state that since the late 1990s, when initial returns increased considerably, many researchers started to be doubtful whether asymmetric information alone is enough to explain the level of underpricing. Ritter and Welch (2002) note, more recent studies stress the importance of share allocation and trading-related explanations, notably the allocation between institutional and individual investors.

Loughran and Ritter (2002) study the conflict of interest between issuers and the underwriters and stress that the underwriters may intentionally utilize their discretion power in share allocation and leave more money on the table than what would be in the best interests of the issuing firm. Pulliam and Smith (2000, 2001) state shares might be allocated to favor the underwriter's buy-side clients in return for quid pro quos or to practice "spinning" (Siconolfi, 1997) by offering part of the underpriced shares to third party executives in exchange for future business. In addition, Hanley and Wilhelm (1995), and Aggarwal, Prabhala, and Puri (2002) provide evidence that institutions, who are better informed and more important clients for the underwriters, are favored in share allocation processes. Consistently, Booth and Chua (1996), Brennan and Franks (1997), Mello and Parsons (1998), and Stoughton and Zechner (1998) show the phenomena of underpricing creates excess demand and therefore allows issuers and the underwriters to decide to whom allocate the shares. However, underwriters may not only influence the aftermarket price by decisions made pre-IPO but by actively participating in the

aftermarket. In addition, underwriters do not only have influence on the share price, but the quantity of shares offered.

Carter and Manaster (1990) show that the initial public offerings by well reputed underwriters are associated with less risk and therefore result in lower levels of underpricing than the offerings by less reputed underwriters. Investors are more confident with the highly reputed underwriters as they can use their broad customer base to achieve a successful issue, hence lowering the risk of the offering and decreasing the level of the underpricing (Carter, Dark & Singh, 1998; Corwin & Schultz, 2005). On the other hand, underwriters' lower reputation attracts short-term investors who search for flipping opportunities and quick gains. Well reputed underwriters, instead, draw the attention of long-term investors and help in improving the long-term performance of the listing company.

2.2 Long-term underperformance

Numerous researchers have demonstrated the anomaly of long-term underperformance in newly issued stocks both internationally and in the United States. However, the theoretical explanations for long run performance are less abundant than for the underpricing, and the findings are controversial and conflicting (Thomadakis et al. 2012).

2.2.1 Fads, overoptimism, and the window of opportunity

Aggarwal and Rivoli (1990) published one of the first papers to demonstrate long-term underperformance, when they studied the performance of 1598 IPOs on the Nasdaq stock exchange between 1977 and 1987. However, Aggarwal and Rivoli (1990) only investigate a 1-year period after the first day of trading, resulting in an adjusted return of -13.7%, which is hypothesized to be a result of investing fads.

Ritter (1991) then examines the long-term performance of initial public offerings in a three-year period, which is one of the most often used timespan for the long-term performance studies, and reports a -29.1% cumulative average abnormal return for 1526 IPOs from 1975 to 1984, matched by industry and size. He provides evidence that many companies carry out their IPOs near the peak of industry-specific fads, which is in line with the arguments of Aggarwal and Rivoli (1990). In addition, Ritter finds evidence of two other hypotheses for the long-term

underperformance, market overoptimism and timing. First, he explains that investors are overreacting to new IPOs, which partly explains the underpricing phenomenon, too. On the other hand, firms tend to go public when investors have high expectations for growth and profits and are therefore willing to pay high multiples that lean on forecasts, which often prove to be overoptimistic. Loughran et al. (1994) further study the hypothesis of timing new issues and find a negative relationship between the IPO volume and following year's market return. The paper from Lerner (1994) further strengthens the hypothesis of the window of opportunity, when he examines 350 venture capital backed biotechnology firms and illustrates that companies tend to go public at market peaks, whereas rely on private financing when multiples and valuations are low.

2.2.2 Choice of methodology and benchmark

Academic researchers typically employ either the cumulative abnormal return (CAR) or buy and hold return (BHAR) approach when studying the long run performance of newly issued stocks. However, these methodologies often result in different conclusions and may play a major role in interpreting the analysis. Ahmad-Zaluki et al. (2007) report mixed findings on the long-term share price performance of Malaysian IPOs in the period of 1990 to 2000. In contrast to previous literature, a significant overperformance is demonstrated in equally weighted CARs and BHARs, when using two market benchmarks. However, the findings became insignificant when the value-weighted method or a matched company benchmark was studied. Also, when Ahmad-Zaluki et al. (2007) applied the calendar-time approach using Fama-French three-factor model, the significant abnormal performance disappeared, indicating that the even-time approach provides a more positive return in the long run. Roll (1983) argues that the approach of cumulative abnormal returns may be a misleading measure for the anomaly of long-term performance because of its nature in reweighting the portfolio returns every month, and thus showing spurious abnormal returns where there is none. Further Conrad and Kaul (1993) and Barber and Lyon (1997) suggest that the best methodology to study the stock price performance in the long run is the buy and hold return strategy, which does not bias the negative long run returns due to monthly rebalancing. Nevertheless, numerous papers witness the anomaly of long-term underperformance irrespective of the methodology used (Keloharju, 1993; Espenlaub et al. 1998).

To reach optimal results and draw accurate conclusions, the most appropriate benchmark to adjust the returns and evaluate long-term performance would be a sample of comparable companies matched by size, industry, and the market. Because of the challenges in constructing such a portfolio of comparable firms, academic researchers typically use a market index as benchmark that best corresponds to the companies analyzed. Dimson and Marsh (1986) argue that in computing abnormal returns, the selected benchmark may significantly alter the conclusions of aftermarket performance. Levis (1993), and Loughran and Ritter (1995), however, provide evidence that the central finding of mean long run performance is not sensitive to the selected benchmark, even though the magnitude of the abnormal performance fluctuates.

3. Data and methods

3.1 Data Collection

The study is based on data of companies that went public in the main lists of NYSE and Nasdaq stock exchange between January 2003 and December 2019. The sample consists of 1811 IPOs with the intention to study the impact of company characteristics on short-term underpricing and long-term underperformance before, during, and after the global financial crisis. In the sample, 574 and 1237 IPOs were launched on the NYSE and Nasdaq stock exchange, respectively.

Sample selection	
Number of original IPOs issued in the period of January 2003 to December 2019 on NYSE and Nasdaq-US stock exchange, excluding closed-end funds and trusts	2691
Excluding REITs and other but main Nasdaq and NYSE initial public offerings	-131
Excluding American Depositary Shares (ADS) and Receipts (ADR), Units, LPs, and LLCs	-68
Removing offerings with insufficient data	-59
Excluding offerings below $5 per share	-10
	1811

The IPO sample was collected from the Thomson Reuters Eikon data platform. Additionally, information of the filing and issue dates, offer price, industry, stock exchange, proceeds ($), type of shares, and whether the issue was backed by a venture capital (VC) or private equity (PE) investor were collected from the Eikon database. Stock market data was collected from the Center for Research in Security Prices (CRSP) to calculate the IPO underpricing and long-term performance for each listed company, and to adjust the data with S&P 500 stock market index. Company financials and market information were collected from the Compustat database and to test the reliability, all the outliers or otherwise doubtful information were checked individually from the latest annual reports before the offering, provided by the U.S. Securities and Exchange Commission. Finally, to study the long-term performance, the stock market data was adjusted for splits by using the information provided by CRSP and BNK Invest, an owner and operator of a variety of online properties, including Split History.

3.2 Description of the sample

3.2.1 Division between NYSE and Nasdaq stock exchange

The sample consists of initial public offerings in the main lists of NYSE and Nasdaq stock exchange, the two largest stock exchanges in the world measured both in the size of the market and the monthly trading volume. It is of interest in this study to run a comparison in the underpricing and long-term performance in these two markets due to their fundamental differences. While Nasdaq is known for growth-oriented high-technology companies that run more risk and uncertainty in their operations, NYSE attracts more stable and mature companies.

Share of companies going public on NYSE and Nasdaq represent 31.7% and 68.3% of the total sample, respectively. However, the share of IPOs on the NYSE has increased by more than seven percentage points over the sample period when comparing pre-financial crisis times to the post-financial crisis times. Thus, the share of IPOs on the NYSE already represents 34.0% of the offerings between 2010 and 2019, while the share was only 26.8% in 2003-2006. It is noteworthy, however, that Nasdaq has dominated the IPO market again in 2018 and 2019, accounting for 74.4% and 78.7% of all new IPOs, respectively.

Table 2: IPOs categorized by the stock exchange, total sample

The table shows the total number of IPOs in the sample per year, the division between the two stock exchanges, and a combination of the data before, during and after the global financial crisis. On the right side, the mean proceeds of an IPO per year and by stock exchange are presented.

	Number of IPOs			Mean proceeds, $ million		
	Total	**NYSE**	**Nasdaq**	**Total**	**NYSE**	**Nasdaq**
2003	58	16	42	151,85	233,23	120,84
2004	158	40	118	143,01	294,99	91,49
2005	136	43	93	176,51	370,56	86,79
2006	129	30	99	164,23	409,98	89,77
2007	134	32	102	172,42	341,35	121,18
2008	19	7	12	1 120,12	2 843,31	114,93
2009	42	20	22	332,36	372,97	295,44
2010	92	37	55	314,61	619,13	109,74
2011	81	33	48	299,11	539,07	133,45
2012	90	39	51	319,54	233,02	385,69
2013	145	62	83	269,69	431,39	148,90
2014	196	70	126	208,73	401,25	101,78
2015	112	31	81	183,08	346,05	120,71
2016	69	19	50	134,71	239,39	94,93
2017	109	38	71	220,15	445,29	99,66
2018	133	34	99	195,63	436,68	107,53
2019	108	23	85	339,72	836,61	205,27
2003–2006	481	129	352	159,24	339,26	93,26
2007–2009	194	59	135	299,21	648,91	148,62
2010–2019	1136	386	750	245,20	442,76	143,53
2003–2019	**1811**	**574**	**1237**	**228,24**	**440,69**	**129,81**
% of total	*100.0 %*	*31.7 %*	*68.3 %*			

3.2.2 Industry classification

Another objective of this study is to examine the impact of the industry on IPO underpricing and long-term performance as well as study the different industry characteristics individually. Thus, the sample is divided into seven different industry categories based on company descriptions and SIC Codes: financial, manufacturing, mining and construction, other, services, TCEGS (transportation, communications, electric, gas, and sanitary service), and wholesale and retail trade. However, only six industries are examined individually because of the low number of companies falling into the "other" section.

Table 3: IPOs categorized by the industry, total sample

The IPOs are divided into different industry categories based on their SIC Code at the time of the offering. Mining and Construction include SIC Codes 1000-1799, manufacturing 2000-3999, TCEGS 4000-4999, Wholesale and Retail Trade 5000-5999, Financial 6000-6799, Services 7000-8999, and Other the rest.

	Financial	Manufacturing	Mining and Construction	Other	Services	TCEGS	Wholesale and Retail Trade
2003	11	18	1	0	13	9	6
2004	27	66	7	0	31	11	16
2005	26	49	8	0	26	14	13
2006	16	64	8	0	27	6	8
2007	15	60	6	0	39	9	6
2008	3	8	0	0	7	1	0
2009	4	10	2	2	16	3	5
2010	24	31	3	0	23	5	6
2011	17	22	4	0	29	3	7
2012	16	31	5	0	25	1	12
2013	24	54	9	0	40	6	12
2014	36	80	10	0	51	6	13
2015	11	56	1	0	28	5	11
2016	7	31	2	0	19	4	6
2017	22	43	7	1	23	4	9
2018	17	62	6	1	37	3	7
2019	12	44	1	0	39	3	9
2003–2006	80	197	24	0	97	40	43
2007–2009	21	78	8	2	62	13	11
2010–2019	185	454	48	2	314	40	92
2003–2019	**286**	**729**	**80**	**4**	**473**	**93**	**146**
% of total	*15.8 %*	*40.3 %*	*4.4 %*	*0.2 %*	*26.1 %*	*5.1 %*	*8.1 %*

3.2.3 VC-backed, PE-backed, and high-technology companies

In the sample, 46.5% of the listings were backed by venture capitalists and only 28.9% by private equity funds. Also, only one company in the sample had both venture capital and private equity investors as owners at the time of the IPO. Hence, 448 companies, representing 24.7% of the sample, had no sponsors to back their IPOs. Interestingly, the share of VC-backed offerings has increased significantly since 2003, reaching its current peak in 2019, whereas the share of PE-backed IPOs has decreased accordingly.

High-tech companies cover 54.1% of the sample IPOs on the NYSE and Nasdaq stock exchange and the share percentage has only been increasing over the sample period. Notably, no less than two thirds of all the IPOs in 2019 were executed by high-tech companies, the highest share in the sample.

Table 4: Share of VC-backed, PE-backed, and high-tech IPOs, total sample

Total number of IPOs is presented on the left column at an annual level as well as before, during, and after the financial crisis. Additionally, quantity and share percentage of VC-backed, PE-backed, and high-technology companies are shown. Note, only one company in the sample, Acacia Communications Inc, had both sponsor types backing their offering in 2016.

		VC-backed		PE-backed		High-tech	
	Number of IPOs	**N**	**%**	**N**	**%**	**N**	**%**
2003	58	25	43.1 %	19	32.8 %	31	53.4 %
2004	158	74	46.8 %	43	27.2 %	84	53.2 %
2005	136	42	30.9 %	59	43.4 %	64	47.1 %
2006	129	56	43.4 %	45	34.9 %	65	50.4 %
2007	135	72	53.3 %	34	25.2 %	78	57.8 %
2008	19	7	36.8 %	6	31.6 %	7	36.8 %
2009	42	11	26.2 %	20	47.6 %	22	52.4 %
2010	92	41	44.6 %	28	30.4 %	36	39.1 %
2011	82	36	43.9 %	23	28.0 %	41	50.0 %
2012	90	40	44.4 %	32	35.6 %	44	48.9 %
2013	145	64	44.1 %	51	35.2 %	68	46.9 %
2014	196	96	49.0 %	61	31.1 %	112	57.1 %
2015	112	62	55.4 %	28	25.0 %	74	66.1 %
2016	69	34	49.3 %	19	27.5 %	36	52.2 %
2017	109	44	40.4 %	25	22.9 %	68	62.4 %
2018	133	70	52.6 %	20	15.0 %	79	59.4 %
2019	108	69	63.9 %	11	10.2 %	72	66.7 %
2003–2006	481	197	41.0 %	166	34.5 %	244	50.7 %
2007–2009	195	90	45.9 %	60	30.6 %	107	54.6 %
2010–2019	1135	556	48.9 %	298	26.2 %	630	55.5 %
2003–2019	**1811**	**843**	**46.5 %**	**524**	**28.9 %**	**981**	**54.1 %**

When looking the data in more detail, we can notice that major portion of the VC-backed and high-technology companies execute their IPOs on the Nasdaq stock exchange, whereas most PE-backed corporations list themselves on the NYSE market. However, VC-backed, and high-technology companies have significantly increased their portion of the new issues in the New York stock exchange, too. On the other hand, the share of PE-backed companies has declined in both stock exchanges throughout the sample period, indicating that the funds have increasingly placed emphasis on exit strategies other than IPOs.

Table 5: Share of VC-backed, PE-backed and high-tech IPOs on the NYSE, total sample

Here the sample quantity of VC-backed and PE-backed IPOs, and their share percentage of the total offerings on the NYSE is presented. Additionally, the number and the share percentage of high-technology companies is shown on the right column. Note, in this sample 58.1% of the high-technology firms running an IPO on the NYSE are also backed by a venture capital.

	NYSE					
	No. of VC	***VC-%***	**No. of PE**	***PE-%***	**No. of HT**	***HT-%***
2003	0	0.0 %	9	56.3 %	3	18.8 %
2004	7	17.5 %	21	52.5 %	8	20.0 %
2005	2	4.7 %	30	69.8 %	12	27.9 %
2006	4	13.3 %	15	50.0 %	4	13.3 %
2007	5	15.6 %	17	53.1 %	9	28.1 %
2008	2	28.6 %	2	28.6 %	1	14.3 %
2009	3	15.0 %	12	60.0 %	6	30.0 %
2010	10	27.0 %	20	54.1 %	8	21.6 %
2011	8	24.2 %	16	48.5 %	15	45.5 %
2012	14	35.9 %	21	53.8 %	18	46.2 %
2013	19	30.6 %	30	48.4 %	22	35.5 %
2014	23	32.9 %	35	50.0 %	28	40.0 %
2015	14	45.2 %	15	48.4 %	17	54.8 %
2016	2	10.5 %	12	63.2 %	2	10.5 %
2017	9	23.7 %	17	44.7 %	9	23.7 %
2018	10	29.4 %	11	32.4 %	12	35.3 %
2019	10	43.5 %	5	21.7 %	12	52.2 %
2003–2006	13	10.1 %	75	58.1 %	27	20.9 %
2007–2009	10	16.9 %	31	52.5 %	16	27.1 %
2010–2019	119	30.8 %	182	47.2 %	143	37.0 %
2003–2019	**142**	**24.7 %**	**288**	**50.2 %**	**186**	**32.4 %**

Table 6: Share of VC-backed, PE-backed and high-tech IPOs on the Nasdaq, total sample

Here the sample quantity of VC-backed and PE-backed IPOs, and their share percentage of the total offerings on the Nasdaq stock market is presented. Additionally, the number and the share percentage of high-technology companies is shown on the right column. Note, in this sample 77.0% of the high-technology firms running an IPO on the Nasdaq stock exchange are also backed by a venture capital.

	Nasdaq					
	No. of VC	***VC-%***	**No. of PE**	***PE-%***	**No. of HT**	***HT-%***
2003	25	59.5 %	10	23.8 %	28	66.7 %
2004	67	56.8 %	22	18.6 %	76	64.4 %
2005	40	43.0 %	29	31.2 %	52	55.9 %
2006	52	52.5 %	30	30.3 %	61	61.6 %
2007	67	65.0 %	17	16.5 %	69	67.0 %
2008	5	41.7 %	4	33.3 %	6	50.0 %
2009	8	36.4 %	8	36.4 %	16	72.7 %
2010	31	56.4 %	8	14.5 %	28	50.9 %
2011	28	57.1 %	7	14.3 %	26	53.1 %
2012	26	51.0 %	11	21.6 %	26	51.0 %
2013	45	54.2 %	21	25.3 %	46	55.4 %
2014	73	57.9 %	26	20.6 %	84	66.7 %
2015	48	59.3 %	13	16.0 %	57	70.4 %
2016	32	64.0 %	7	14.0 %	34	68.0 %
2017	35	49.3 %	8	11.3 %	44	62.0 %
2018	60	60.6 %	9	9.1 %	67	67.7 %
2019	59	69.4 %	6	7.1 %	60	70.6 %
2003–2006	184	52.3 %	91	25.9 %	217	61.6 %
2007–2009	80	58.4 %	29	21.2 %	91	66.4 %
2010–2019	437	58.3 %	116	15.5 %	472	62.9 %
2003–2019	**701**	**56.6 %**	**236**	**19.0 %**	**780**	**63.0 %**

3.2.4 Long-term performance sample

The long-term performance is measured as a three-year market-adjusted return for each offering. However, only the IPOs that were carried out between 2003 and 2016 are included into the sample. Also, if an issuing firm is delisted from NYSE or Nasdaq stock exchange before the three-year anniversary, the study truncates its BHAR and CAR on that date.

Sample selection	
Number of the IPOs in total sample	1811
Excluding IPOs that were executed between 2017 and 2019	-350
	1461

The total sample size for the study of long-term performance consists of 1461 IPOs of which 33.5% were performed on the NYSE and 66.5% on the Nasdaq stock exchange.

Table 7: IPOs categorized by the stock exchange, long-term performance study

This table shows the total number of IPOs used in the study of long-term performance. In addition, the division between the two stock exchanges as well as a combination of the data before, during and after the global financial crisis are presented. On the right side, the mean proceeds of an IPO per year and by stock exchange are presented.

	No. of IPOs			Mean proceeds, $ million		
	Total	**NYSE**	**Nasdaq**	**Total**	**NYSE**	**Nasdaq**
2003	58	16	42	151,85	233,23	120,84
2004	158	40	118	143,01	294,99	91,49
2005	136	43	93	176,51	370,56	86,79
2006	129	30	99	164,23	409,98	89,77
2007	134	32	102	172,42	341,35	119,43
2008	19	7	12	1 175,35	2 843,31	113,92
2009	42	20	22	327,56	372,97	288,07
2010	92	37	55	314,61	619,13	109,74
2011	81	33	48	299,11	539,07	134,14
2012	90	39	51	319,54	233,02	385,69
2013	145	62	83	269,69	431,39	148,90
2014	196	70	126	208,73	401,25	101,78
2015	112	31	81	183,08	346,05	120,71
2016	69	19	50	134,71	239,39	94,93
2003–2006	481	129	352	159,24	339,26	93,26
2007–2009	195	59	136	299,21	648,91	147,50
2010–2016	785	291	494	244,26	412,01	145,45
2003–2016	**1461**	**479**	**982**	**223,60**	**421,60**	**127,03**
of total %	*100.0 %*	*32.8 %*	*67.2 %*			

When comparing tables 1 and 6, that is, the data samples in the IPO underpricing and long-term performance studies, the main difference is that the companies listed in 2017-2019 are excluded from the latter. Consequently, the mean proceeds decreased from $228.24 to $223.60 million, and the share of IPOs on the NYSE market increased from 31.7% to 32.8%. This is in line with the fact that Nasdaq has dominated the IPO market in recent years. It is also worth mentioning that the Nasdaq attracts more growth companies, for which an IPO has proven to be a prominent opportunity to raise capital and increase reputation in recent years. As a result, technology companies are listing themselves on an increasing scale and the Nasdaq's share of all American IPOs is growing.

3.3 Methodology

The returns are calculated in two different intervals to study the underpricing and long-term performance of the newly issued stocks. The initial return is measured as the difference between the confirmed offer price and the closing price of first-day trading, which is then adjusted for market movements. The long-term performance, instead, is calculated as the difference in 3-year stock performance in comparison to the main market index, S&P 500. Both intervals are then further studied to better understand the impact of market and company characteristics on initial returns and long-term performance, with special focus on the industry differences and sponsorship before, during, and after the global financial crisis.

3.3.1 IPO Underpricing

To test the hypothesis of IPO underpricing, I use the conventional method presented by Ritter (1984) to first calculate the raw initial returns:

$$RIR_{i,t} = \frac{P_{i,1} - P_{i,0}}{P_{i,0}} \qquad (1)$$

$P_{i,1}$ is the price at the end of the first day of trading and $P_{i,0}$ is the offer price. The raw initial returns, however, do not take the general market movements into account, and thus the prices need to be adjusted with a benchmark index:

$$MAIR_{i,t} = \frac{P_{i,1} - P_{i,0}}{P_{i,0}} - \frac{MI_{i,1} - MI_{i,0}}{MI_{i,0}} \qquad (2)$$

where $MI_{i,1}$ is the market index price at the end of the first trading day and $MI_{i,0}$ is the latest value of the index before the first day of trading. Since the data set in this study is large and heterogeneous, and the only common factors that apply for the whole data sample are that the firms are US based and the IPOs were carried out in either NYSE or Nasdaq stock exchange, I use the S&P 500 index as a benchmark. S&P 500 stock index is a market-capitalization-weighted index consisting of the largest 500 publicly traded companies in the United States, thus representing the common market movements closely, where the firms of the IPO sample operate.

3.3.2 Long-term performance

In this study, the long-term performance is measured as a three-year relative return in comparison to the market index, S&P 500, using the conventional method of cumulative abnormal returns, CAR. This method was initially used by Ritter (1991) in his study of the long-run performance in the US between 1975 and 1984. While the initial return period is defined as the difference between the offer price and the first-day closing price, the long-run performance period includes the following 36 months of trading.

Monthly market-adjusted returns are calculated as the monthly raw return for each offering minus the corresponding monthly return of the benchmark stock index, S&P 500. Thus, the benchmark-adjusted return for stock i in month t is defined as:

$$ar_{i,t} = r_{i,t} - r_{m,t} \qquad (3)$$

$r_{i,t}$ is the monthly stock price return of stock i on month t, excluding the initial return
$r_{m,t}$ is the corresponding monthly return of the benchmark index

The abnormal returns ($AR_{i,t}$) represent the stock returns earned by the company after the adjustment of the market returns. Any significant difference is considered as abnormal or excess return. Hence, $AR_{i,t}$ is the difference between the actual and expected rates of return on stock i at time t. Then, the average market-adjusted return or the average abnormal return (AAR_t) on a sample of N IPOs for event month t is the equally weighted arithmetic average:

$$AR_t = \frac{1}{N} \cdot \sum_{i=1}^{n} ar_{i,t} \qquad (4)$$

Finally, the cumulative average market-adjusted return (CAR_T) from month 1 to T is the summation of the equally-weighted average market-adjusted returns:

$$CAR_T = \sum_{t=1}^{T} AR_t \qquad (5)$$

To test the null hypothesis that the mean cumulative abnormal return is equal to zero for a sample of N IPOs, I follow the parametric t-statistic test presented by Ritter (1991):

$$t_{CAR} = \frac{\mathrm{CAR_{i,t}} \cdot \sqrt{n}}{\sqrt{t \cdot var + 2 \cdot (t-1) \cdot cov}} \quad (6)$$

$\mathrm{CAR_{i,t}}$ is the cumulative average abnormal return from month 1 to t
var is the cross-sectional variance over the period of 36 months
cov is the first-order autocovariance of the AR_t series

In addition to the cumulative average market-adjusted return, I use an alternative method of Ritter (1991) and calculate the average long-run buy-and-hold abnormal return (BHAR) to measure long-term performance. Barber and Lyon (1997) suggest that BHAR is more appropriate for evaluating the long-run performance of IPO stocks than the CAR. Furthermore, Lyon et al. (1999) argue that results from the BHAR method measure the real buy-and-hold experience of investors and are thus more important in measuring the experience for IPO stocks.

As an alternative measure to the CAR, the buy-and-hold return, where the stock is purchased at the price of first-day closing after the IPO and held until T, is defined as:

$$BHR_{i,T} = \prod_{t=1}^{T}(1 + r_{i,t}) - 1 \quad (7)$$

T is the number of months
$r_{i,t}$ is the raw return of stock i for month t

The return of the market index is calculated in the same manner. Based on Kooli and Suret (2004), the buy-and-hold abnormal return, BHAR, is therefore measured as follows:

$$BHAR_T = \left[\prod_{t=1}^{T}(1 + r_{i,t}) - 1\right] - \left[\prod_{t=1}^{T}(1 + r_{m,t}) - 1\right] \quad (8)$$

$r_{m,t}$ is the return of market index during the corresponding period

The equally-weighted mean buy-and-hold abnormal return over T month, and for a sample of N IPOs is hence defined as:

$$\overline{BHAR}_T = \frac{1}{N} \cdot \sum_{i=1}^{N} \left[\prod_{t=1}^{T} (1 + r_{i,t}) - 1 \right] - \left[\prod_{t=1}^{T} (1 + r_{m,t}) - 1 \right] \quad (9)$$

To test the null hypothesis of average buy-and-hold return is equal to zero for a sample of N IPOs, I employ a bootstrapped skewness-adjusted t-statistic test, used by Lyon et al. (1999):

$$t_{BHAR} = \sqrt{n} \cdot \left(S + \frac{1}{3} \hat{\gamma} \cdot S^2 + \frac{1}{6n} \hat{\gamma} \right) \quad (10)$$

where

$$S = \frac{\overline{BHAR}_t}{\sigma(BHAR_t)} \quad (11)$$

$$\hat{\gamma} = \frac{\sum_{i=1}^{n} \left(BHAR_{i,t} - \overline{BHAR}_t \right)^3}{n \cdot \sigma(BHAR_t)^3} \quad (12)$$

$\hat{\gamma}$ is an estimate of the coefficient of skewness.

Under the null hypothesis, if the sample is drawn randomly from a normal distribution, the t-test follows a Student's t-distribution when the sample size is small. However, even if adjusting for the performance of the market returns, CARs and BHARs tend to be skewed to the right. Hence, skewness in the excess returns induce a skewness bias to the long-term performance test statistics (Barber & Lyon, 1997). While the non-symmetric distribution of the long-term returns is true in theory, the extent of the bias in the parametric t-statistic test for the hypothesis of "mean abnormal long-term return is equal to zero" is expected to decline when the sample size N increases. Further, since the t-test assumes that all IPOs are independent, the statistical central limit theorem (CLT) guarantees that the distribution of the sample approximates normal distribution as the sample size becomes larger, regardless the population distribution shape. Despite all, considering the risk of the skewness bias, a bootstrapped skewness adjusted t-statistic test allows the most robust conclusions in the study of long-term performance.

3.3.3 Multivariate OLS regression

Majority of the prior literature studying initial returns and long-term performance of the newly issued stocks have utilized statistical regression models in their empirical tests (see Hanley, 1993; Michaely & Shaw, 1994; Loughran & Ritter, 2004). The objective is to estimate the relationship between the dependent and explanatory variables. The most common form of the regression analysis is the linear regression, where the relationship is modelled using linear prediction functions whose unknown model parameters are estimated from the data. Ordinary least squares (OLS) is a statistical method for estimating the unknown parameters by minimizing the sum of squares of the differences between the observed dependent variable and those predicted by the linear function. The OLS regression, however, has underlying assumptions to produce the best estimates:

1. The regression model is linear in the coefficients and the error term
2. The error term has a population mean of zero
3. All independent variables are uncorrelated with the error term
4. Observations of the error term are uncorrelated with each other
5. The error term has a constant variance
6. No independent variable is a perfect linear function of other explanatory variables

If all assumptions hold, the OLS regression model is consistent, unbiased and efficient. Under these assumptions, the estimators determined by the OLS are known as Best Linear Unbiased Estimators (Brooks, 2008).

In the examination of initial returns, I run multivariate regressions to examine the significance of different company and industry characteristics on the IPO underpricing.

Table 8: List of explanatory variables in the study of IPO underpricing

Interpretation of the independent variables: Proceeds, Total Assets, Days Between Filing and Issue, Industry, Primary Exchange, High-Tech, VC-Backed IPO, PE-Backed IPO, and Share Types.

Explanatory variables	Interpretation
Proceeds	Number of shares offered multiplied by the offer price. For regression purposes, the logarithmic values are used.
Total Assets	Total assets as stated in the latest annual report before the issue. For regression purposes, the logarithmic values are used.
Days Between Filing and Issue	Number of days between the SEC filing, and issue of the IPO for each company. For regression purposes, the logarithmic values are used.
Dummy Variables	
Primary Exchange	Value one is assigned for securities that are traded on the Nasdaq stock exchange, whereas value zero for the securities listed on the NYSE.
High-Tech	Value one is assigned for companies that are considered high-tech in the Eikon database, whereas value zero is assigned for the rest.
VC-Backed IPO	If the company was backed by a venture capital company, value one is assigned. Otherwise, dummy takes a value of zero.
PE-Backed IPO	If the company was backed by a private equity company, value one is assigned. Otherwise, dummy takes a value of zero.
Share Type	Dummy variable based on the type of the shares. If the company offered existing shares of common stock in the IPO, dummy takes a value of one. Otherwise, the value zero is assigned.

The analysis that is performed to evaluate if and how the explanatory variables are related to the dependent variables of initial return is the multiple linear regression. The fundamental version of the OLS multivariate regression model is phrased as:

$$MAIR_i = \beta_0 + \beta_1 ln(Proceeds)_i + \beta_2 ln(Total\ Assets)_i + \beta_3 ln\ (Days)_i + \beta_4 HighTech_i + \beta_5 VC_i + \beta_6 PE_i + \beta_7 Primary\ Exchange_i + \beta_8 Share\ Type_i \quad (13)$$

$MAIR_i$ is the market-adjusted initial return for stock i.

4. Findings

4.1 Underpricing

4.1.1 Total sample statistics

In the total sample period of 2003-2019, IPOs listed on the NYSE and Nasdaq main markets averaged an underpricing level of 14.87% and raised $228.2 million in equity. The highest level of initial return, 231.25%, was experienced in 2019 by Monopar Therapeutics Inc, when the price increased from $8.0 to $26.5 per share during the first day of trading. The highest level of overpricing, instead, took place in 2017 when Funko Inc lost 41.1% of the issue value in one day.

Table 9: IPO statistics of initial returns, proceeds, and total assets

The table shows the mean, median, maximum, minimum, and standard deviation statistics of the initial returns (both raw and S&P 500 adjusted), proceeds, and total assets of the total sample of 1811 listed companies.

	Initial Return %			
Statistic	**Raw**	**Market adjusted**	**Proceeds $M**	**Total Assets $M**
Mean	14.9 %	14.8 %	228.24	1 442.43
Median	8.0 %	7.9 %	100.00	128.29
Maximum	231.3 %	230.8 %	17 864.00	235 648.00
Minimum	-41.1 %	-41.1 %	3.49	0.01
Std. Dev.	25.2 %	25.2 %	762.19	9 830.81
N	1811	1811	1811	1811

To first test the hypothesis of the IPO underpricing, I run the parametric one sample t-test to find the p-value:

$$t_{IR} = \frac{\overline{IR} - \mu}{s_{IR}/\sqrt{n}} \qquad (14)$$

$\overline{IR}$ is the mean initial return of the sample

μ is the expected initial return, here zero

s_{IR} is the standard deviation of the initial returns.

Given the statistics in table 8, the p-value for the underpricing in the sample of 1810 degrees of freedom is 0.000, and the hypothesis of zero initial returns can be rejected. This result is in line with the previous research and gives basis for the more comprehensive studies.

The mean initial returns have fluctuated from year to year as demonstrated in figure 2. Surprisingly, the lowest mean initial return was experienced in the middle of the financial crisis, in 2008, when the stock price increased on average 6.3% during the first day of trading. The highest mean initial return was seen in 2019, when the closing price after first day of trading was on average 23.6% higher than the offer price. Interestingly, IPOs experienced on average higher underpricing after the financial crisis than before or during the crisis, and there has been a significant upward trend since 2017.

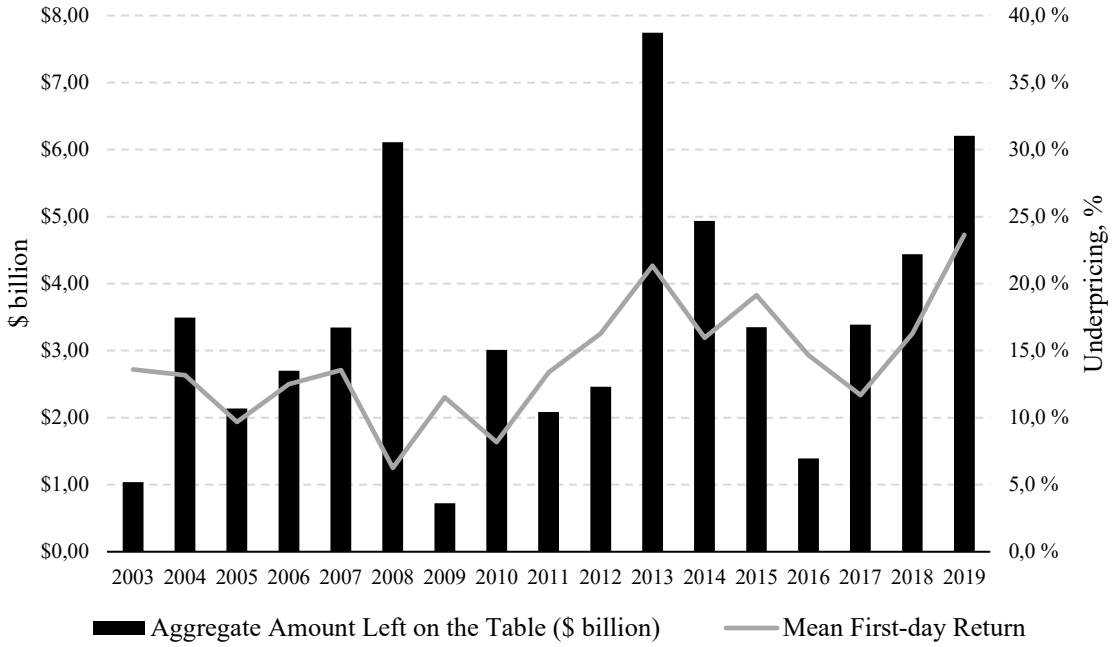

Figure 1: Mean First-Day Returns and Money Left on Table, 2003-2019

The figure shows the equal-weighted mean initial returns for the sample of 1811 IPOs in 2003-2019. In black the aggregate amount of money left on the table is presented, which is defined as the proceeds-weighted mean first-day return multiplied by the number of shares offered.

Money left on table is defined as the difference between the offer price and the closing price on the first day trading, multiplied by the number of shares offered. This rewards positive financial returns for the initial investors but leaves such money on the table that the company could have raised with a higher offer price. Hence, it represents a transfer of wealth from the current owners of the issuing company to the investors who participate in the initial public offering.

Like initial returns, also the aggregate amount left on table fluctuates considerably from year to year. The highest values were experienced in 2008 and 2013, when $6.11 billion and $7.74 billion were left on table, respectively. On the other hand, only $1.04 billion was left on table in 2003, and $0.72 billion in 2009. There has been no clear trend between the years 2003 and 2019, and no significant differences before, during and after the financial crisis. However, the annual aggregate money left on table does follow the number of IPOs per year to some extent, even if some discrepancy, like the year 2008, can be noticed.

In 2003, the number of IPOs remained very low because of the aftermath of the tech bubble, which caused natural uncertainty in the stock markets. However, the NYSE and the Nasdaq stock market recovered quickly in 2004 and the number of new IPOs remained stable for some years. A new plunge was experienced in the beginning of the financial crisis, whereafter the number of IPOs increased year by year until 2014, which was the largest IPO year in terms of volume since the dotcom bubble. This happened because of a great increase in tech issuance, particularly biotech.

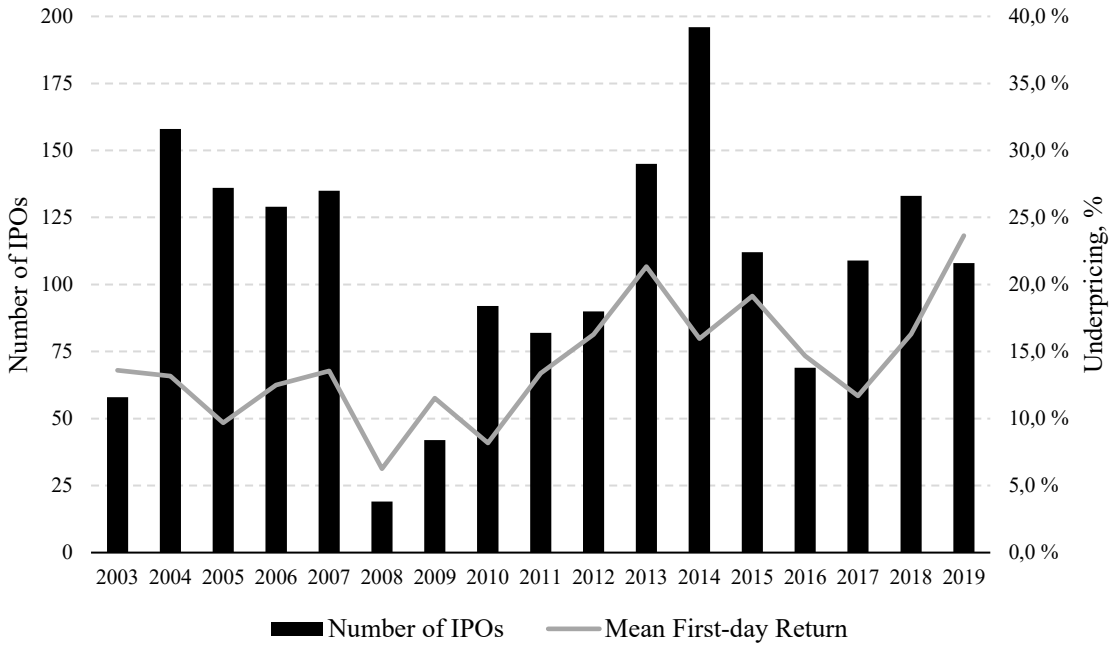

Figure 2: Number of IPOs and Mean First-Day Returns, 2003-2019

The figure shows the equal-weighted mean initial returns for the sample of 1811 IPOs in 2003-2019. Also, the number of IPOs per year is presented to picture the relationship between the aggregate amount of money left on table in figure 2 and the number of IPOs.

Since there were several tech IPOs in 2014, and investors poured a lot of money into these hot startups, there was a striking decrease in the number of new IPOs in 2015. Then, the IPO market for tech companies was a lackluster in 2015, and consequently the number of new IPOs in 2016

decreased even more. As a result of uncertain market conditions, companies with high valuation and a sufficient amount of cash decided to wait for a more favorable market environment, which provoked a higher number of IPOs for 2017-2019.

4.1.2 Initial return of the high-tech, VC-backed, and PE-backed IPOs

The share of high-tech, VC-backed, and PE-backed IPOs of the total sample remained relatively stable throughout the period from 2003 to 2019. For high-tech companies, the unambiguous exception is the year 2008, when only 36.8% of the new offerings were executed by the high-tech firms. Correspondingly, the share of VC-backed IPOs decreased significantly in 2008 yet remained low in 2009, too. In the sample of PE-backed companies, such decrease cannot be recognized at the time of the financial crisis. However, the share of new offerings backed by the private equity funds was substantially lower in 2018 and 2019, when only 15.0% and 10.2% were sponsored, respectively. Meanwhile, the share of high-tech and VC-backed IPOs increased significantly.

Interestingly, both sponsor-backed and high-tech IPOs experienced higher initial returns after the financial crisis than before and during the recession. The only exceptions are the PE-backed offerings that witnessed considerably lower initial returns during the financial crisis. Nevertheless, also the VC-backed companies experienced low initial returns in 2008, when the stock prices increased only on average 3.8% at the first day of trading. Uniquely, high-tech companies even witnessed overpricing of 2.9% in 2008, when only one out of the 7 high-tech IPOs that year was underpriced.

Table 10: Initial returns categorized by high-tech, VC-backed, and PE-backed IPOs

Below are presented the percentages of the high-tech, VC-backed, and PE-backed IPOs of the total number of IPOs per year. Additionally, the mean initial returns of high-tech, VC-backed, and PE-backed IPOs are presented per year as well as before (2003-2006), during (2007-2009), and after (2010-2019) the financial crisis.

					Mean First-day Return		
Year	**Number of IPOs**	**Percentage of High-Tech**	**Percentage of VC-Backed**	**Percentage of PE-Backed**	**Return of High-Tech IPOs**	**Return of VC-Backed IPOs**	**Return of PE-Backed IPOs**
2003	58	53.4 %	43.1 %	32.8 %	12.9 %	16.1 %	13.5 %
2004	158	53.2 %	46.8 %	27.2 %	15.1 %	13.8 %	11.1 %
2005	136	47.1 %	30.9 %	43.4 %	10.9 %	13.4 %	6.2 %
2006	129	50.4 %	43.4 %	34.9 %	11.5 %	15.9 %	9.2 %
2007	134	57.8 %	53.3 %	25.2 %	15.2 %	20.5 %	4.6 %
2008	19	36.8 %	36.8 %	31.6 %	-2.9 %	3.8 %	8.0 %
2009	42	52.4 %	26.2 %	47.6 %	13.1 %	18.6 %	8.7 %
2010	92	39.1 %	44.6 %	30.4 %	8.1 %	9.7 %	6.2 %
2011	81	50.0 %	43.9 %	28.0 %	18.1 %	19.7 %	13.1 %
2012	90	48.9 %	44.4 %	35.6 %	16.1 %	19.4 %	17.9 %
2013	145	46.9 %	44.1 %	35.2 %	23.5 %	28.2 %	19.8 %
2014	196	57.1 %	49.0 %	31.1 %	19.4 %	22.3 %	10.0 %
2015	112	66.1 %	55.4 %	25.0 %	22.4 %	23.1 %	10.8 %
2016	69	52.2 %	49.3 %	27.5 %	18.7 %	21.8 %	10.8 %
2017	109	62.4 %	40.4 %	22.9 %	15.7 %	18.1 %	7.0 %
2018	133	59.4 %	52.6 %	15.0 %	20.9 %	25.3 %	13.1 %
2019	108	66.7 %	63.9 %	10.2 %	25.9 %	23.2 %	29.0 %
2003–2006	481	50.7 %	41.0 %	34.5 %	12.8 %	14.6 %	9.1 %
2007–2009	195	54.6 %	45.9 %	30.6 %	13.6 %	18.9 %	6.3 %
2010–2019	1135	55.5 %	48.9 %	26.2 %	19.0 %	21.9 %	13.2 %
2003–2019	**1811**	**54.1 %**	**46.5 %**	**28.9 %**	**17.4 %**	**19.9 %**	**11.1 %**

4.1.3 Initial returns by the stock exchange

The number of IPOs on the NYSE and the Nasdaq stock exchange have varied significantly from year to year in the period of 2003 to 2019. Also, the relative difference of the new IPOs between the two markets has fluctuated considerably. On average, the number of IPOs on the NYSE account for 50.7% of the new offerings on the Nasdaq. However, the ratio was only 35.9% between 2003 and 2007, increased up to 90.9% in 2009, and remained relatively high until 2014, when it decreased back to 55.6%. This change during the financial crisis and a few years after can be explained with the characteristic differences of the two stock exchanges as described in section 3.2.

The mean initial returns in both markets have fluctuated substantially during the sample period. New offerings on the Nasdaq saw their lowest mean initial return in 2008, when 12 companies went public and faced an average first-day return of 6.8%. In New York stock exchange, the lowest values of underpricing were experienced in 2009 and 2010, when the stock prices increased on average 7.2% and 7.0% at the first-day of trading, respectively. Interestingly, both markets saw extremely high initial returns in 2019, when the values of average underpricing climbed above 22.5%.

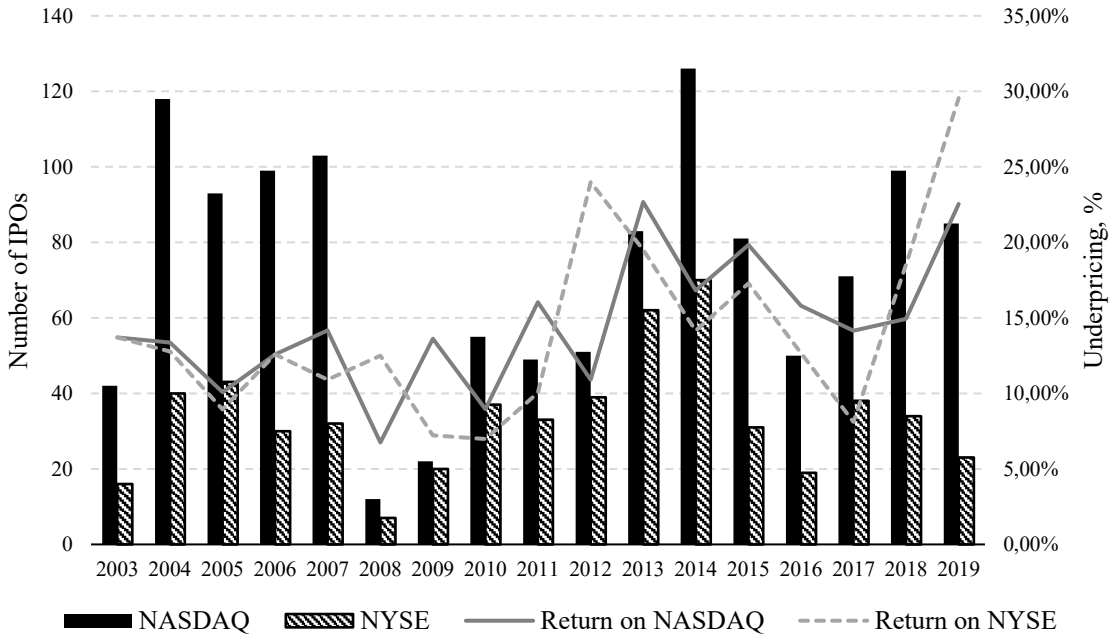

Figure 3: Number of IPOs and initial returns on the NYSE and Nasdaq stock exchange
The figure shows the equal-weighted mean initial returns for the sample of 1237 IPOs on the Nasdaq stock exchange in 2003-2019 and 574 IPOs on the NYSE in 2003-2019. Additionally, the number of IPOs per year is presented to illustrate the differences between the markets, and the potential relation to the underpricing.

4.1.4 Initial returns by the industry

The level of underpricing in different industries are statistically significant. Lowest initial returns occurred in the mining and construction industry, where stock prices increase on average 5.9% at the first day of trading. Moreover, the standard deviation of 12.6% is the lowest of all sectors, suggesting only minor variation around the mean level of underpricing. Also, companies in the TCEGS (transportation, communications, electric, gas, and sanitary service) witness relatively low initial returns in IPOs, with a mean underpricing of 8.3%.

Contrary to Mining and Construction, and TCEGS industries, the largest initial returns are experienced in the Services, and Wholesale and Retail Trade industries, where companies are underpriced on average 21.0% and 22.8%, respectively. These industries also have high standard deviation values, indicating substantial variation around their mean initial return. Manufacturing industry has a large standard deviation, too, but the stock prices of firms are closing on average only 13.0% higher at the first day of trading than their offer price.

The average levels of underpricing have remained relatively stable before, during, and after the financial crisis in almost all sectors. Both the Services, and the Wholesale and Retail Trade industries, however, have experienced significant increase in their mean initial returns after the financial crisis. Interestingly, the annual mean underpricing of the Services industry has varied only between 19.7% and 29.7% after the financial crisis, whereas Wholesale and Retail Trade has witnessed a variation of 1.4% to 56.0% at the corresponding time span.

Table 11: Initial returns categorized by the industry

Below are the initial returns presented in the industry level. The table does not include the item "other" because of the small number of IPOs. Values of mean initial return that are presented in gray color include less than five IPOs and are thus highlighted as relatively ambiguous results. Finally, I present the statistics of the IPOs of each industry in the bottom to illustrate the significance of the underpricing. Note, TCEGS is an abbreviation of Transportation, Communication, Electric, Gas, and Sanitary Services.

	Mean First-day Return						
Year	**Total Sample**	**Financial**	**Manufacturing**	**Mining and Construction**	**Services**	**TCEGS**	**Wholesale and Retail Trade**
2003	13.6 %	5.4 %	10.0 %	5.0 %	23.2 %	4.3 %	13.0 %
2004	13.2 %	7.6 %	9.1 %	10.1 %	20.8 %	13.6 %	16.0 %
2005	9.7 %	7.9 %	10.4 %	9.6 %	9.1 %	6.1 %	12.5 %
2006	12.5 %	13.4 %	10.7 %	6.3 %	14.9 %	6.4 %	21.9 %
2007	13.5 %	8.2 %	11.9 %	3.6 %	18.0 %	11.5 %	18.3 %
2008	6.3 %	7.8 %	5.0 %	NA	4.5 %	23.4 %	NA
2009	11.5 %	24.2 %	13.1 %	-0.5 %	14.8 %	1.8 %	8.5 %
2010	8.2 %	10.0 %	8.2 %	2.7 %	9.0 %	6.4 %	8.4 %
2011	13.4 %	12.7 %	6.0 %	-0.8 %	22.8 %	2.9 %	29.9 %
2012	16.3 %	13.2 %	12.0 %	11.0 %	28.2 %	31.4 %	13.1 %
2013	21.3 %	9.1 %	16.1 %	9.0 %	29.7 %	8.3 %	56.0 %
2014	16.0 %	9.9 %	16.2 %	5.0 %	21.4 %	11.9 %	23.8 %
2015	19.1 %	15.1 %	18.6 %	16.5 %	21.6 %	-5.8 %	37.3 %
2016	14.7 %	6.4 %	9.9 %	-5.6 %	29.2 %	8.3 %	16.3 %
2017	11.7 %	7.1 %	10.6 %	-0.0 %	19.7 %	18.5 %	11.4 %
2018	16.3 %	12.0 %	15.8 %	6.9 %	26.1 %	4.4 %	1.4 %
2019	23.6 %	23.1 %	20.5 %	10.7 %	24.5 %	15.5 %	54.3 %
2003–2006	12.1 %	8.5 %	10.0 %	8.5 %	16.3 %	7.8 %	15.6 %
2007–2009	12.4 %	11.1 %	11.3 %	2.6 %	15.7 %	10.1 %	13.9 %
2010–2019	16.4 %	10.9 %	14.6 %	5.2 %	23.5 %	8.3 %	27.2 %
2003–2019	**14.9 %**	**10.5 %**	**13.0 %**	**5.9 %**	**21.0 %**	**8.3 %**	**22.8 %**
N	1 811	286	729	80	473	93	146
Std dev.	25.2 %	14.5 %	26.0 %	12.6 %	27.7 %	16.8 %	31.9 %
Max	231.3 %	68.9 %	231.3 %	47.4 %	217.0 %	67.9 %	163.0 %
Min	-41.1 %	-21.4 %	-41.1 %	-20.8 %	-33.1 %	-29.6 %	-26.0 %
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

4.1.5 Multivariate regression analysis of initial returns

The OLS regression analysis is divided into two sections: First, I study the relationship of underpricing and independent variables in the total sample and in different periods of issue. The periods in which the sample is divided are the time before the financial crisis, during the financial crisis, and the period after. In addition, the independent variables are kept constant in all models to provide an effective comparability, as shown in table 11. In the second section, I explore the characteristics of different industries on IPO underpricing by examining the relationship of identical explanatory variables and their significance on initial returns. Results of the second section are presented in table 12. Multivariate regression analysis is run in all cases and used as a baseline to the total sample of 1811 IPOs.

Regression analysis by issue period

This section brings light to the relationship of several explanatory variables on IPO underpricing between 2003 and 2019. I also demonstrate the relationship of the independent variables and market adjusted initial returns at the time of the financial crisis as well as before and after the recession. The independent variables are explained in a more profound manner in table 7 at section 3.3.3 Multivariate OLS regression. Lastly, I present the r-squared values for each model to evince the explanatory power of the overall model.

The value of the adjusted r-squared for the total sample of 1811 IPOs is 0.062, indicating that the model can explain only a fraction of the variance of market adjusted initial returns. However, the r-squared value increases at 0.200 over the financial crisis, implying that the regression model explains 20.0% of the variance in IPO underpricing, and that the independent variables have a stronger explanatory value of the initial returns during the crisis than before and after. This could suggest that companies listed during the crisis were larger and more mature, and thus easier to value than companies before and after the crisis. The low R2 are nonetheless in line with the previous literature. Beatty and Ritter (1986) note that high r-squared would imply that the actual initial return of an IPO would be predictable.

Variables that are statistically significant in the total sample, include proceeds or the money raised during the IPO, size of total assets, number of days between filing and the issue of shares,

venture capital as financial sponsor, and existing or secondary shares issued in the process. All the variables mentioned are statistically significant at 1% level, whereas private-equity backing, high-tech companies, or the stock exchange do not explain the first-day abnormal returns, and hence are statistically insignificant.

Interestingly, the size of the total assets loses part of its explanatory value on IPO underpricing when the total sample is distributed into the three different issue periods. Larger assets indicate slightly lower initial returns for stocks listed before and after the financial crisis. However, the size of the assets does not explain the underpricing of stocks that performed their offering at the time of the financial crisis. Correspondingly, the days between filing and issue loses its statistical significance in explaining the initial returns when the sample is distributed into the three periods. Only the abnormal first-day returns, which occurred after the great recession can be explained with the number of days before the stocks start trading.

Financial sponsors bring capital for private companies among important contacts, operational and financial experience, and strategic help. Going public is a conventional exit plan for the private equity and venture capital companies, and the support seem to have a significant impact on underpricing, too. From 2003 to 2006, private equity backed companies could have expected smaller abnormal returns during the first-day of trading than companies without the private equity support. However, during and after the crisis, PE-backed companies do not show any significant difference in the underpricing. Venture capital backed companies, instead, face higher initial returns during and after the recession even if the VC sponsored companies do not show statistically significant abnormal returns between 2003 and 2006.

The only two variables that remain statistically significant in all three periods are gross proceeds (logarithmic function) and the combined/secondary issue. In other words, the more companies raise money during the IPO process the higher initial returns are expected. Also, companies that sell a significant amount of existing shares when going public can expect higher level of underpricing. Such companies may have a concern of ex-ante demand for stocks, and hence sell the shares with a discount.

Table 12: OLS regressions categorized by the issue period

This table shows the results of OLS regressions, where the dependent variable is the market adjusted initial return, MAIR, for the total sample, and samples of issue before, during, and after the financial crisis. The standard errors are adjusted for heteroskedasticity, when necessary, and the results of the two-tailed t-test are presented in parentheses after the adjustment. The statistical significance of the coefficients is reported as follows: *significant at 10%, ** significant at 5%, *** significant at 1%.

Independent variable	Total Sample	Pre-Crisis	Financial Crisis	Post-crisis
Constant	0.045	-0.014	-0.169	0.047
	(0.798)	*(-0.184)*	*(-1.532)*	*(0.660)*
ln (Proceeds)	0.045***	0.048***	0.088***	0.037***
	(5.409)	*(3.912)*	*(4.849)*	*(3.305)*
ln (Total Assets)	-0.012***	-0.013**	-0.024	-0.010*
	(-2.751)	*(-2.006)*	*(-1.539)*	*(-1.745)*
ln (Days Between Filing and Issue)	-0.024***	-0.010	-0.023	-0.019**
	(-3.743)	*(-0.987)*	*(-1.345)*	*(-2.349)*
Venture Capital DUMMY	0.083***	0.024	0.135***	0.095***
	(4.269)	*(0.877)*	*(3.134)*	*(3.556)*
Private Equity DUMMY	-0.009	-0.051***	-0.026	0.018
	(-0.678)	*(-2.700)*	*(-0.854)*	*(0.944)*
High-Tech DUMMY	0.002	-0.013	-0.044	0.019
	(0.152)	*(-0.582)*	*(-1.299)*	*(0.829)*
Nasdaq DUMMY	0.009	0.023	0.050	0.007
	(0.620)	*(0.998)*	*(1.530)*	*(0.338)*
Combined/Secondary Issue DUMMY	0.040***	0.057***	0.069***	0.035**
	(3.532)	*(3.375)*	*(2.475)*	*(2.053)*
Heteroscedasticity testing				
Breusch-Pagan p-value	0.000	0.001	0.026	0.013
White-test p-value	0.000	0.000	0.001	0.011
Adjustment on Robust Standard Errors	Yes	Yes	Yes	Yes
N	1811	481	195	1135
Adjusted R^2	0.062	0.076	0.200	0.049

Regression analysis by industry

This section shows the relationship of explanatory variables on IPO underpricing between 2003 and 2019 in following industries: financial, manufacturing, mining and construction, services, TCEGS (transportation, communications, electric, gas, and sanitary service), and wholesale and retail trade. Interestingly, many variables lose their explanatory value on IPO underpricing when analyzing the sample in an industry level. However, the r-squared remain low in all models indicating that they can still explain only a fraction of the variance in market adjusted initial returns.

The multivariate regression model of the financial industry has the highest R2, but the statistically significant variables are very different from the total sample. FinTech companies are expected to face significantly higher market-adjusted initial returns than the finance,

insurance, and real estate companies operating in more conventional businesses. Also, the venture capital backed financial companies are prone to experience deeper underpricing than the non-sponsored or private equity backed counterparties. Finally, higher gross proceeds are expected to increase the abnormal returns at first-day of trading, like in the total sample, but surprisingly no other variable has significant explanatory power on IPO underpricing in the financial industry. Wholesale and retail trade and services sectors show similar statistical significance of the variables, except for the days between filing and issue in the services industry, where a longer period is expected to decrease the initial returns.

The highest number of companies executing an IPO come from the manufacturing sector, covering approximately 40% of the offerings in the total sample. Nevertheless, the regression model has the lowest r-squared value, signifying that only 4.6% of the variance in IPO underpricing can be explained by the model. Interestingly, the private equity dummy is significant at 5% level, suggesting that PE-backed companies encounter significantly lower initial returns in the manufacturing industry than the other manufacturing companies going public. Additionally, the combined/secondary issue dummy is significant at 5% level albeit the variable stays insignificant in other industries. The only exception is TCEGS (transportation, communications, electric, gas, and sanitary service), where the combined/secondary issue dummy is the only variable with explanatory power on IPO underpricing, meaning that the issuing companies face on average 10.3% higher initial returns, when secondary shares are issued in the process.

Table 13: OLS regressions categorized by the industry

This table shows the results of OLS regressions, where the dependent variable is the market adjusted initial returns, MAIR, for the total sample and samples of different industries. The industry section "other" is excluded due to low number of IPOs. The standard errors are adjusted for heteroskedasticity, when necessary, and the results of the two-tailed t-test are presented in parentheses after the adjustment. The statistical significance of the coefficients is reported as follows: *significant at 10%, ** significant at 5%, *** significant at 1%.

Independent variable	Total Sample	Financial	Manufacturing	Mining and Construction	Services	TCEGS	Wholesale and Retail Trade
Constant	0.045	0.081	0.043	-0.208	0.076	-0.032	-0.114
	(0.798)	*(1.424)*	*(0.437)*	*(-1.347)*	*(0.549)*	*(-0.207)*	*(-0.416)*
ln (Proceeds)	0.045***	0.018*	0.057***	0.015	0.064**	0.012	0.130**
	(5.409)	*(1.949)*	*(3.474)*	*(0.654)*	*(2.240)*	*(0.487)*	*(2.465)*
ln (Total Assets)	-0.012***	-0.005	-0.011	0.018	-0.030	-0.020	-0.043
	(-2.751)	*(-0.910)*	*(-1.304)*	*(1.221)*	*(-1.528)*	*(-1.101)*	*(-1.347)*
ln (Days Between Filing and Issue)	-0.024***	-0.014	-0.029**	0.008	-0.025*	0.023	-0.044
	(-3.743)	*(-1.622)*	*(-2.275)*	*(0.433)*	*(-1.880)*	*(1.119)*	*(-1.552)*
Venture Capital DUMMY	0.083***	0.127***	0.018	0.125*	0.101**	0.057	0.256**
	(4.269)	*(2.779)*	*(0.609)*	*(1.888)*	*(2.162)*	*(1.074)*	*(2.331)*
Private Equity DUMMY	-0.009	0.016	-0.087**	0.035	-0.012	0.025	0.090
	(-0.678)	*(0.869)*	*(-2.446)*	*(1.133)*	*(-0.338)*	*(0.555)*	*(1.418)*
High-Tech DUMMY	0.002	0.161**	0.001		0.058**	-0.038	-0.140*
	(0.152)	*(2.313)*	*(0.046)*		*(2.254)*	*(-0.985)*	*(-1.525)*
Nasdaq DUMMY	0.009	0.017	-0.001	0.084**	-0.021	0.016	0.077
	(0.620)	*(0.902)*	*(-0.037)*	*(2.085)*	*(-0.714)*	*(0.392)*	*(1.116)*
Combined/Secondary Issue DUMMY	0.040***	-0.001	0.057**	-0.009	-0.017	0.103***	0.017
	(3.532)	*(-0.047)*	*(2.153)*	*(-0.334)*	*(-0.752)*	*(2.884)*	*(0.305)*
Heteroscedasticity testing							
Breusch-Pagan	0.000	0.000	0.426	0.181	0.032	0.107	0.005
White Test	0.000	0.000	0.271	0.230	0.036	0.193	0.000
Adjustment on Robust Standard Errors	Yes	Yes	No	No	Yes	No	Yes
N	1811	286	729	80	473	93	146
Adjusted R^2	0.062	0.154	0.046	0.053	0.093	0.095	0.109

4.2 Long-term Performance

Gombers and Lerner (2003) argue that the results of long-run performance differ depending on the empirical methodology used. Therefore, to control for the robustness of the long-term performance of newly issued stocks and to draw reliable conclusions, both CAR and BHAR methods are studied. In addition, both equal-weighted and market-value weighted portfolios are examined with the BHAR method.

4.2.1 Cumulative Abnormal Returns

Figure 4 illustrates the cumulative raw return and cumulative market-index adjusted return (CARs) of 1461 IPOs in the United States between 2003 and 2016 over the period of 36 months trading. The initial return of the sample is excluded from the calculations, that is, the cumulative returns are computed from the first day closing price. However, the lines of raw and market-adjusted returns are drawn from the equally-weighted initial return for illustrative purposes. The IPOs yield an initial return of 14.2% during the first day of trading.

The newly issued stocks experience their first peak after three months of trading, reaching a raw and market-adjusted cumulative return of 5.6% and 3.7%, respectively. Table 13 shows that the peak is statistically significant, indicating that the IPOs overperform the market during the first quarter of trading, after which the stock prices decrease back to the level of the market index. Over the 3-year period, IPOs yield a 25.2% return after the first day of trading, leading to a 5.9% overperformance when controlled with the market index, S&P 500. The overperformance is both statistically and economically significant, hence conflicting with the previous literature.

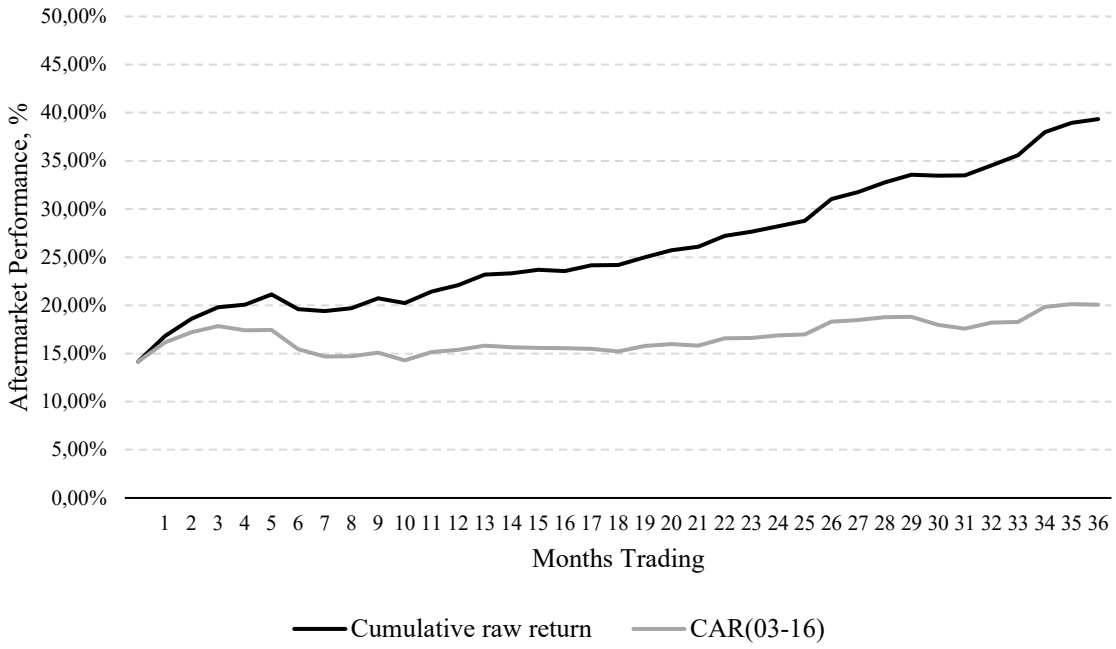

Figure 4: Mean Cumulative Raw and Market-adjusted Returns in 2003-2016

The figure shows the monthly mean cumulative returns for the total sample of 1461 IPOs during the first 36 months, beginning from the average initial return of the first day trading, 14.2%. In grey, the raw cumulative return of the portfolio is presented and in black the cumulative market-adjusted return.

The monthly average abnormal returns vary between a negative 2.0% in month six and a positive 2.0% during the first month of trading, excluding the initial returns. The cumulative average abnormal return peak at month 35 reaching a total return of 6.0%. Twelve of the 36 months of cumulative abnormal returns are statistically significant, emphasizing the notable overperformance during the first five months of trading and the months between 34 and 36. However, CARs are mostly insignificant between these two periods, implying that there is no major difference in the performance of IPOs between the months 6 and 33 when compared to the performance of the market index. In other words, the 1461 US IPOs between 2003 and 2016 experience, on average, similar returns from the first half year of trading to the end of month 33 as the S&P 500 index but outperform the market in the first five and last three months of trading prior reaching the three-year threshold as publicly listed companies.

Table 14: Abnormal Returns for Initial Public Offerings in 2003-2016

This table demonstrates average market-index adjusted returns (AR_t) and cumulative average market-adjusted returns (CAR_t) with associated t-statistic for the 36 months after running an IPO, excluding the initial first-day returns. The number of trading companies begins at less than 1461 as some firms have a delay of one or two months after the IPO before becoming listed. The t-statistic for the average market-adjusted returns is computed for each month as $AR_t \cdot \sqrt{n_t}/sd_t$, where sd_t is the cross-sectional standard deviation of the adjusted returns in month t. The t-statistic for the cumulative average market-adjusted returns is computed for each month as $CAR_{1,t} \cdot \sqrt{n_t}/csd_t$, where csd_t is computed as $csd_t = [t \cdot var + 2 \cdot (t-1) \cdot cov]^{1/2}$, where var is the 36-month cross-sectional variance, and cov is the first-order autocovariance of the AR_t series.

Month of seasoning	Number of IPOs trading	AR_t	t-statistic	CAR_t	t-statistic
1	1448	2.0 %	4.574	2.0 %	4.238
2	1459	1.1 %	2.348	3.0 %	4.654
3	1461	0.6 %	1.482	3.7 %	4.621
4	1459	-0.4 %	-1.013	3.3 %	3.540
5	1459	0.0 %	0.098	3.3 %	3.210
6	1458	-2.0 %	-4.794	1.3 %	1.156
7	1456	-0.8 %	-1.930	0.5 %	0.436
8	1454	0.0 %	0.074	0.6 %	0.431
9	1453	0.4 %	0.875	0.9 %	0.678
10	1451	-0.8 %	-2.014	0.1 %	0.092
11	1448	0.8 %	2.018	1.0 %	0.639
12	1442	0.2 %	0.542	1.2 %	0.755
13	1436	0.5 %	1.077	1.7 %	1.002
14	1433	-0.2 %	-0.430	1.5 %	0.863
15	1428	-0.1 %	-0.184	1.4 %	0.784
16	1423	0.0 %	-0.071	1.4 %	0.740
17	1415	-0.1 %	-0.123	1.3 %	0.686
18	1407	-0.3 %	-0.522	1.1 %	0.535
19	1399	0.6 %	1.192	1.6 %	0.797
20	1391	0.2 %	0.398	1.8 %	0.869
21	1389	-0.2 %	-0.390	1.7 %	0.769
22	1380	0.8 %	1.597	2.4 %	1.089
23	1369	0.1 %	0.107	2.5 %	1.085
24	1363	0.3 %	0.523	2.7 %	1.177
25	1353	0.1 %	0.145	2.8 %	1.181
26	1340	1.3 %	2.726	4.1 %	1.695
27	1330	0.2 %	0.375	4.3 %	1.732
28	1315	0.3 %	0.566	4.6 %	1.809
29	1302	0.0 %	0.048	4.6 %	1.778
30	1294	-0.8 %	-1.835	3.8 %	1.433
31	1281	-0.4 %	-0.969	3.4 %	1.255
32	1271	0.6 %	1.220	4.1 %	1.458
33	1259	0.1 %	0.144	4.1 %	1.455
34	1247	1.5 %	1.882	5.7 %	1.962
35	1238	0.3 %	0.576	6.0 %	2.026
36	1228	-0.1 %	-0.077	5.9 %	1.972

When the data is divided into three different time periods, several changes can be identified in the long-term performance of newly issued stocks. Figure 5, figure 6, and figure 7 illustrate the mean cumulative raw and market-adjusted returns of the different time periods, and numerical monthly and cumulative returns as well as the corresponding t-statistics are set out in the appendices.

Figure 5 shows the cumulative raw and market adjusted return over a 36-month period for 481 IPOs in the United States between 2003 and 2006. The IPOs yield an initial return of 13.3%, after which they exceed the market return over the first five months of trading. Companies that went public in 2003-2006 also outperform the market in months 9-16 after the IPO, but do not show any statistically significant stock performance since then. Thus, these firms performed as well on the stock market as the market in general, and no underperformance can be identified. Interestingly, the IPOs between 2003 and 2006 yield a raw cumulative return of 9.7% after three years of trading. This long-term return is considerably low but can be explained with the subprime mortgage crisis and the ensuing financial crisis that hit hard on several companies listed between 2004 and 2006. Nevertheless, the three-year performance of the data remains insignificant when controlling with outliers from the crisis era.

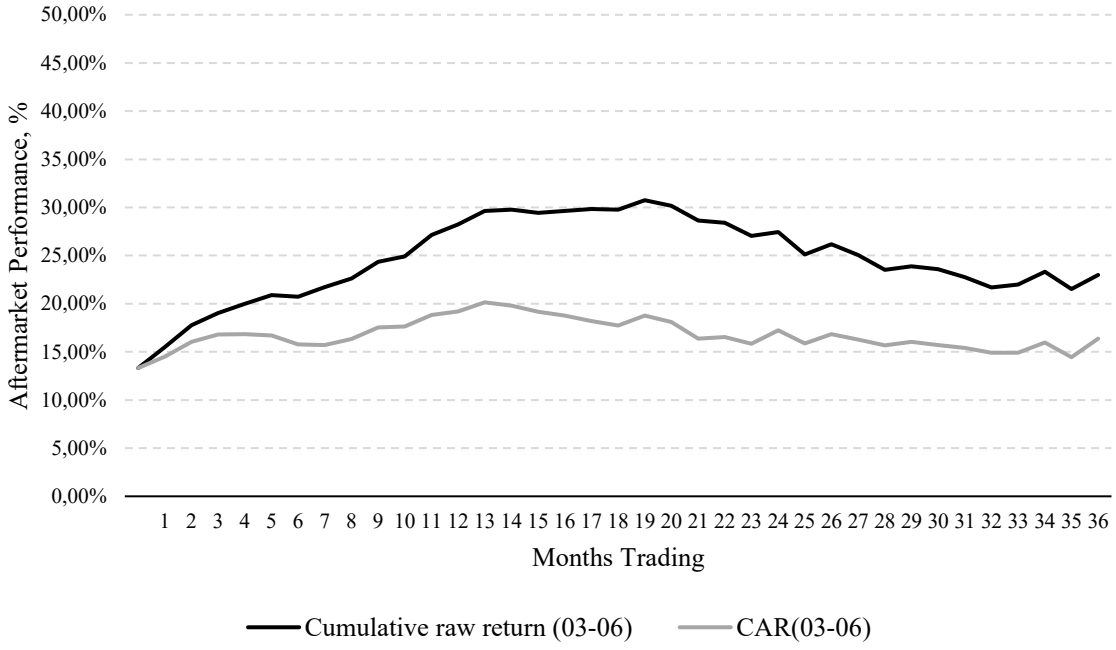

Figure 5: Mean Cumulative Raw and Market-adjusted Returns in 2003-2006
The figure shows the monthly mean cumulative returns for the total sample of 481 IPOs during the first 36 months, beginning from the average initial return of the first day trading, 13.3%. In grey, the raw cumulative return of the portfolio is presented and in black the cumulative market-adjusted return.

The 195 IPOs that were executed between 2007 and 2009 show significantly different characteristics in the raw and market-adjusted cumulative returns than the corresponding data before and after the crisis. After experiencing an average initial return of 11.7%, the IPOs that were executed in 2007-2009 remain mainly insignificant during the first two years of trading. Thereafter, the IPOs outperform the market significantly over the next 12 months, reaching a cumulative market-adjusted return of 33.8% over the total 36-month period, starting from the first-day closing price. Interestingly, 71.8% of companies which performed an IPO between 2007 and 2009 outperformed the S&P 500 index over the first three-year period of trading.

Similarly, as in the offerings between 2003 and 2006, also the long-term stock performance of IPOs in 2007-2009 can be partially explained with the subprime mortgage crisis and the ensuing financial crisis. Companies, on average, performed poorly on the stock market during the first 15 months, but developed remarkably fast once the recession was over. In figure 6, it is worth noticing that the chart of cumulative market-adjusted returns remains higher than the chart of cumulative raw returns. This is due to the low and negative returns of the S&P 500 during the crisis. Consequently, it can be assumed that the weak stock price performance at the beginning and the rapid stock price development after the crisis is due to the market uncertainty for IPOs between 2007 and 2009, which also reflected into the low offer prices. However, companies that performed an IPO during the crisis were, on average, strong companies on solid operational footing, hence mainly overperforming the market during months 16-36.

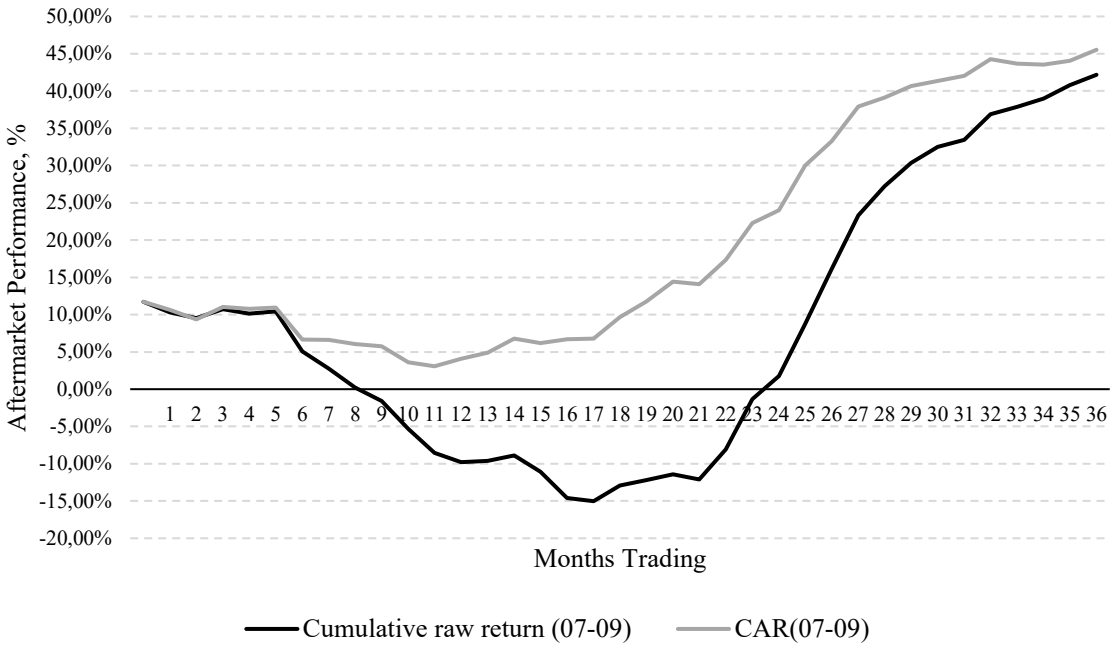

Figure 6: Mean Cumulative Raw and Market-adjusted Returns in 2007-2009

The figure shows the monthly mean cumulative returns for the total sample of 195 IPOs during the first 36 months, beginning from the average initial return of the first day trading, 11.7%. In grey, the raw cumulative return of the portfolio is presented and in black the cumulative market-adjusted return.

Figure 7 illustrates the long-term performance of IPOs on the NYSE and Nasdaq stock markets between 2010 and 2016. The sample of 785 IPOs resembles the total sample with high initial returns and steady increase in the cumulative raw stock price performance after the first year of trading. However, only the first five months of cumulative market-adjusted returns are statistically significant, after which the data remains insignificant. Even if the IPOs yield, on average, a 33.1% cumulative raw return over the 36-month period, no statistically significant difference can be stated when controlling with the market index. Thus, no long-term underpricing anomaly can be identified with the newly issued stocks in the United States between 2010 and 2016.

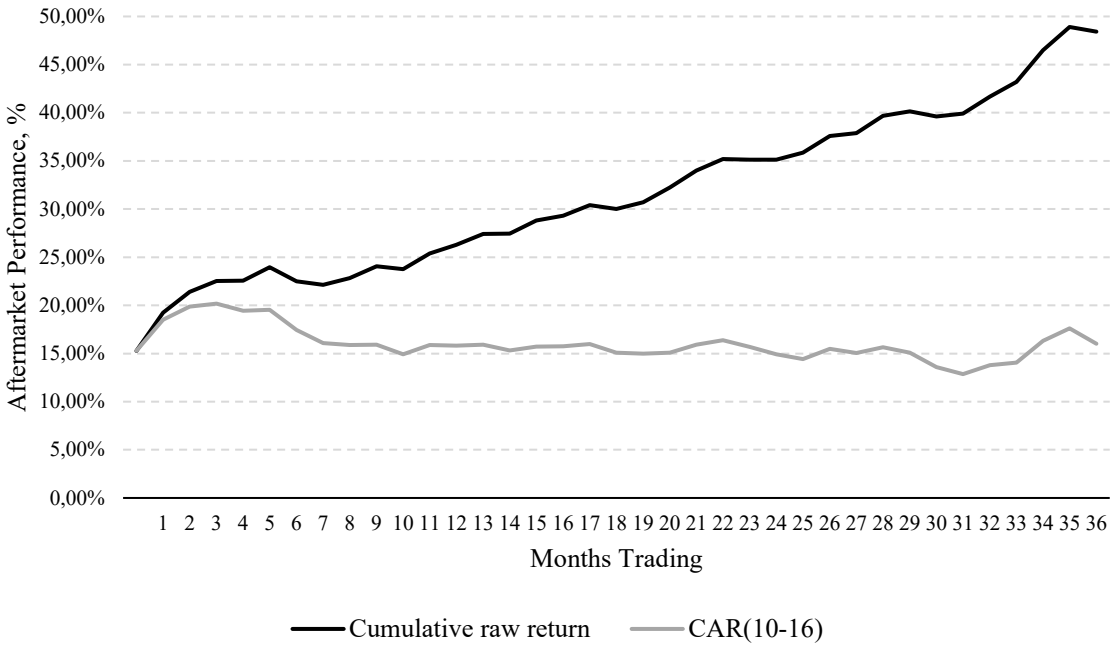

Figure 7: Mean Cumulative Raw and Market-adjusted Returns in 2010-2016

The figure shows the monthly mean cumulative returns for the total sample of 785 IPOs during the first 36 months, beginning from the average initial return of the first day trading, 15.3%. In grey, the raw cumulative return of the portfolio is presented and in black the cumulative market-adjusted return.

Interestingly, the CAR method cannot find any statistically significant underperformance with the newly issued stocks between 2003 and 2016 even if the data is divided into the three subsamples based on the issue year. The method, however, encounters criticism in the literature for monthly rebalancing to maintain equal weights, and thus underweighting the negative stock returns and inflating the long-term returns. Therefore, the additive characteristic of CARs yield to positively biased test statistics and do not resemble well the actual investor experience of owning shares. Lyon et al. (1999) refer the underweighting issue as rebalancing bias and Barber and Lyon (1997) as measurement bias.

To test the robustness, I also study the long-term performance with the buy-and-hold abnormal returns (BHAR) method. This passive multiplicative approach resembles better the actual investor experience by putting heavier weight on negative stock returns. However, BHAR suffers from disadvantages, too, such as the skewness bias. The long-run buy-and-hold abnormal returns are positively skewed, because it is relatively common to observe a sample IPO with an annual return in excess of 100%, but less usual to find a return of this size on the benchmark index. Since the market-adjusted abnormal returns are calculated as the annual sample stock return minus the corresponding market index return, the abnormal returns are positively skewed. This bias is taken into account in the bootstrapped skewness-adjusted

t-statistic computations to prevent the negative bias, which arises from the positive correlation between sample means and sample standard deviations in positively skewed distributions. In addition, the skewness bias in test statistics declines along with the increasing sample size, which in this study is satisfied with over 1400 IPOs.

4.2.2 Buy-and-Hold Abnormal Returns

The BHAR method provides several advantages over the CAR when analyzing long-term performance of newly issued stocks. Thus, to represent the investor perspective of the long-term returns without monthly rebalancing, I construct both equally-weighted and value-weighted portfolios to examine the anomaly of long-term underperformance over the 36 months of trading. The total sample consists of the same 1461 IPOs on NYSE and Nasdaq stock exchange between 2003 and 2016 as in the CAR calculations, and the S&P 500 index is used as control variable to adjust the daily market movements. Comprehensive data of monthly returns and corresponding t-statistics are presented in the appendices.

Figure 8 illustrates the equally-weighted buy-and-hold raw returns and equally-weighted market-adjusted returns over a 3-year period of trading in the public market. The IPOs yield an initial return of 14.2%, after which they exceed the market return during the first five months of trading. The performance over the first five months of trading is significant at 1% level, but like in the CAR, returns remain insignificant from month 6 onwards. Due to the greater impact of negative returns, raw returns remain slightly lower with the BHAR than with the CAR method. Therefore, by investing in IPOs at the first-day closing price and then holding the position for the subsequent 36 months, investors have achieved in 2003-2016 an average rate of return of 21.9%. However, the three-year average return rises to 36.1% if the initial returns are taken into account. That is, investors were given a position in the equity offering and thus benefitted from the underpricing anomaly. In the long-run, however, the IPO data shows no statistical evidence of underperformance or overperformance on the NYSE and Nasdaq stock exchange.

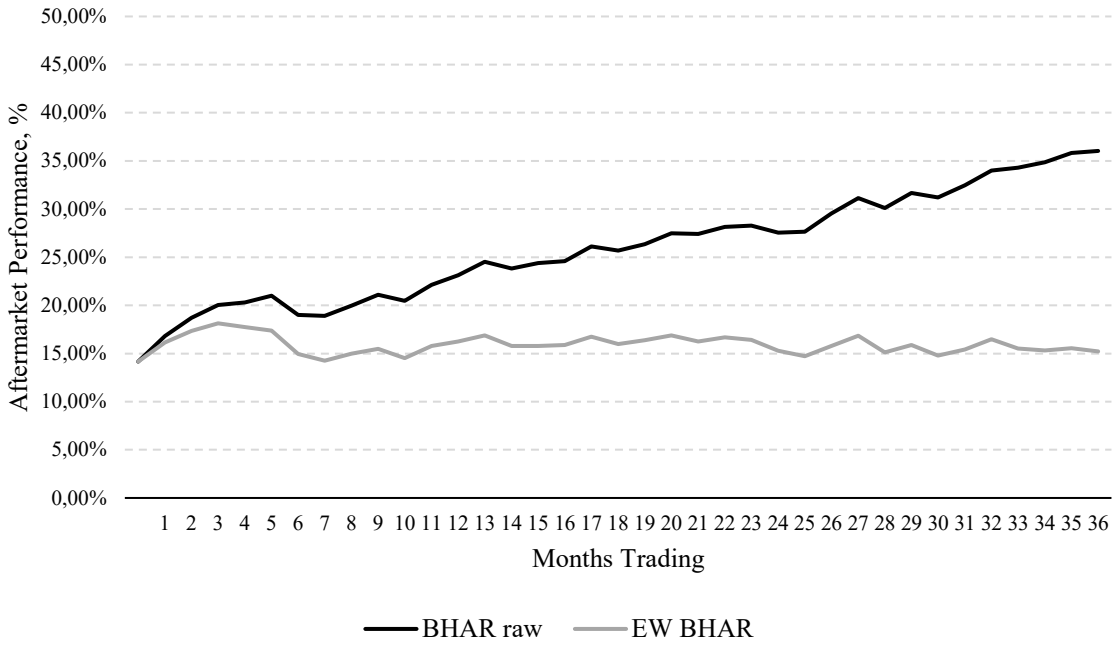

Figure 8: Equal-weighted Buy-and-hold Returns in 2003-2016

The figure presents the monthly equal-weighted buy-and-hold returns for the total sample of 1461 IPOs in the US over the first 36 months of trading, beginning from the average initial return of the first day closing price, 14.2%. In black, the raw buy-and-hold return of the portfolio is presented and in grey the buy-and-hold market-adjusted return.

Fama (1998) note that the anomaly of long-run underperformance usually shrinks when the portfolio of IPO events is weighted by the market capitalization. Thus, value-weighted portfolios are argued to be more practical and accurate in studying the wealth effects experienced by the investors. Since it is of interest in this paper to study the investor perspective on long term performance, figure 9 illustrates the portfolio returns of the value-weighted data.

The value-weighted portfolio experiences notably high initial returns of 20.2%, and outperforms the S&P 500 index during the first four months of trading. Thereafter, the market-adjusted compounding returns remain insignificant and no statistical evidence of overperformance or underperformance can be detected. Interestingly, the raw returns over the first 36-month period of trading is somewhat higher in the value-weighted portfolio than in the equally weighted portfolio. However, since the 36-month market-adjusted performance remains statistically insignificant, higher raw returns suggest that large companies manage to time their IPOs at a more favorable market period than the smaller companies.

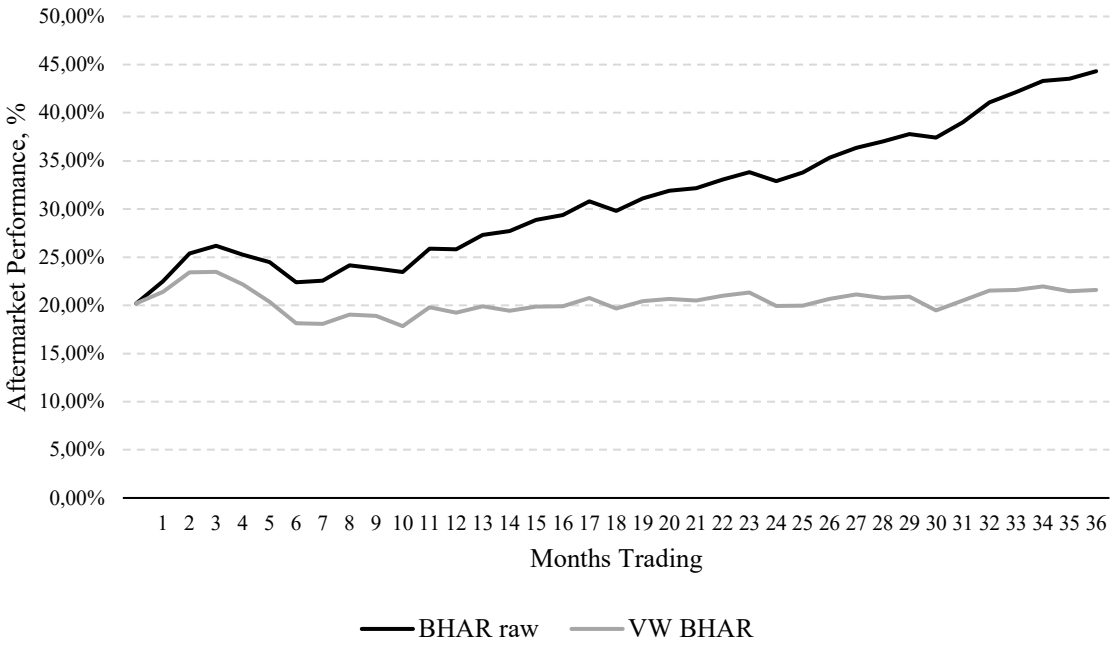

Figure 9: Value-weighted Buy-and-hold Returns in 2003-2016

The figure presents the monthly value-weighted buy-and-hold returns for the total sample of 1461 IPOs in the US over the first 36 months of trading, beginning from the value-weighted average initial return of the first day closing price, 20.2%. In black, the raw buy-and-hold return of the portfolio is presented and in grey the buy-and-hold market-adjusted return.

5. Discussion

This study is performed to analyze the two well-known anomalies, short-term underpricing and long-term underperformance, on the NYSE and Nasdaq stock exchange in the 21st century. The era began with an excessive stock market bubble, which was caused by some preposterous market speculation and ultra-high company valuations. This tech bubble then led to a great stock market crash, when the S&P 500 and the Nasdaq Composite lost 24.8% and 62.7% of their values, respectively, in 2001-2002. Due to this significant yet obscure fluctuation in the market price volatility, I only examine IPOs from year 2003 onwards, which was also a beginning for a relatively steady growth in the US stock market. Although the data consists of American IPOs between 2003 and 2019, I further divide the sample into three subperiods to control the effects of the financial crisis. This allows for a more in-depth analysis of the initial returns and long-term performance of companies that ran their initial public offering during the crisis. Similarly, this division makes it easier to analyze and compare the short and long-term returns before and after the global economic downturn.

5.1 Underpricing

Loughran and Ritter (2004) argue that the level of underpricing vary significantly over time and demonstrate how the average first-day return jumps from 7.4% in the 1980s to 14.8% in 1990-1998, and further to 65.0% in 1999-2000. Moreover, the annual average initial return ranges between 3.6% and 22.3%, when the technology bubble period is excluded, exposing some statistically and economically significant volatility in the mean underpricing from year to year.

In this paper, I continue to examine these findings from Loughran and Ritter (2004) by studying initial returns in the post-tech bubble period, namely 2003-2019, and further divide the sample into three subperiods to explore differences in the global macroeconomic environment. Interestingly, the data show similar mean initial returns albeit slightly less variation from year to year to those demonstrated by Loughran and Ritter (2004) for companies that went public in 1990-1998. The average first-day abnormal return for the total sample is 14.8%, which is exactly the same Loughran and Ritter (2004) discovered for the IPOs in 1990-1998, but the initial returns also remain relatively stable throughout the sample period in 2003-2019. When dividing the sample further into the three different time periods, the average level of

underpricing before and during the financial crisis set at 12.1% and 12.4%, respectively, yet increased at 16.4% after the recession.

The mean initial returns before and after the financial crisis are in line with previous literature and no significant change in the underpricing anomaly can be detected. Even if the economical and societal environment has changed significantly over the last couple of decades through globalization and digitalization, companies tend to experience similar levels of initial returns as in the 1980s and 1990s. Furthermore, despite the fact that the preposterous stock market bubble at the turn of 21st century demonstrated significant underpricing in newly issued stocks, no such trend can be observed with companies listed during the global financial crisis. In fact, when examining and comparing average initial returns in all US economic crises in history, no significant deviation from economic upswings can be identified. Hence, the level of mean initial return over the financial crisis is in line with the historical economic bubbles driven by debt. Equity bubbles characterized by high demand, striking innovations, and hubris, are rather exceptions and witness extreme initial returns. Interestingly, both the aggregate amount of money left on the table and the average level of underpricing have increased since 2017, and as the statistics hit new highs, question arises as to whether we are living in a new stock bubble era.

There has been a change, when analyzing high-technology, venture capital-backed, and private equity-backed companies, that could partly explain the recent growth on first-day abnormal returns. The share of high-tech and VC-backed firms in all new offerings has increased significantly, and since these firms are typically smaller and riskier, they tend to witness higher initial returns, and hence further increasing the level of average underpricing for the entire sample. At the same time, high-tech firms, and VC-backed and PE-backed companies are all experiencing higher levels of underpricing than before the financial crisis. Due to the changing business environment, where increasingly smaller and riskier companies, namely startups, run IPOs to raise funds and address the quality of the company to the markets, the signalling hypothesis suggested by Allen and Faulhaber (1989), Grinblatt and Hwang (1989), and Welch (1989) is possibly explaining part of the increasing trend in initial returns. Besides, these companies are likely to perform a seasoned equity offering, which further strengthens the signalling hypothesis as an explanation for underpricing. Nevertheless, the highest variation and particularly the recent growth of underpricing has occurred in the New York stock exchange, where large companies with lower operational risks tend run their IPO. This is rather

contradictory with the other conclusions, and requires further research to explain the variation in recent initial returns.

5.2 Long-term performance

Although the long-term performance is somewhat less studied than short-term underpricing, researchers largely agree that firms underperform on average during the first three years of trading on a stock market, when controlled with the market index or other benchmark group. However, the previous literature focus heavily on offerings that were carried out in the 20th century, and only a small number of recent publications study the long-term performance of US IPOs, even if the economy has changed substantially and companies going public are smaller yet highly ambitious. Thus, in this paper, I also study the three-year performance of American IPOs that were executed in the NYSE or Nasdaq stock exchange between 2003-2016. Moreover, I control the impact of different methodologies on long-term performance by implementing both of the common methods, CAR and BHAR, and construct both equally-weighted and value-weighted portfolios to maximize robustness of the test results.

The equally-weighted portfolio of 1461 US IPOs in 2003-2016 yield a 25.2% cumulative raw return over the three-year trading period, hence, outperforming the leading market index, S&P 500, with a CAR of 5.9%. The overperformance is statistically significant, hence conflicting with the previous literature. However, when the total sample is divided into three different subperiods in order to control the impact of the financial crisis, it should be noted that the overperformance is fully driven by IPOs executed in 2007-2009, whereas before and after the financial crisis no underperformance or overperformance can be observed. These findings are truly significant and raise the question of whether the conclusions of previous research on long-term underperformance are no longer valid in the 21st century. Also, companies that listed on stock exchange during the financial crisis in 2007-2009 were larger, more solvent, and therefore less risky than other public companies on average. These companies benefited significantly from the economic drivers followed by market upturn, thus outperforming the market on average. Nevertheless, previous hypotheses of fads, overoptimism, and window of opportunity are still valid arguments in explaining the underperformance, as firms listed in a weak or “cold” market period reciprocally perform significantly better than the market in long run.

As stated in the literature review, the methodology of cumulative abnormal returns typically produce higher percentages than the methodology of buy-and-hold abnormal returns in long run. This is because of CAR's nature in rebalancing the portfolio every month, hence weakening the impact of negative long run returns. To test the robustness of the results in long-term performance, I also study the BHAR, but cannot find any statistically significant underperformance, even if the raw returns declined from 25.2% to 21.9%. Finally, I construct both an equally-weighted and value-weighted portfolio to examine the IPO long-term performance in 21st century. Although the raw returns of value-weighted portfolio are higher, and hence and in line with CAR results that larger and less riskier companies perform better in long run, no statistically significant abnormal returns can be detected.

After all, the results are clearly different and inconsistent with previous literature, and no underperformance is observed with companies that went public after the tech bubble. Instead, businesses that run an initial public offering during the global financial crisis even overperformed the market index, S&P 500, over the three-year period. In other words, listed companies tend to perform better on the stock market than before, and the underperformance anomaly has at least momentarily disappeared from the IPO market. However, further research is needed to understand the reasons why underperformance anomaly no longer exists, and whether this is a global phenomenon or only encountered in the US market.

6. Conclusions

In this thesis, I study the short-term underpricing and long-term underperformance of companies listed on the NYSE and Nasdaq stock exchange between 2003 and 2019. I demonstrate that the mean initial return of 14.8% has remained at the same level as in 1990-1998, and that there is only little fluctuation from year to year, despite the fact the market environment has changed substantially. However, the share of high-tech and venture capital-backed companies have been increasing steadily, and because of their smaller size and higher risk-taking capacity, also higher levels of underpricing should be expected. Even if such a trend can be noticed, the more interesting question is whether we in fact live in a new stock market bubble, as the average level of underpricing has been increasing rapidly towards new highs since 2017.

Despite the recent events, the underpricing levels are well in line with previous literature, whereas no significant long-term underperformance can be observed of companies listed in the 21st century. Instead, firms who ran an IPO during the financial crisis even outperformed the market on average over the first three years of trading, while other companies show no significant differences in their stock performance when compared to the benchmark index. These results differ considerably from previous literature, where long-term underperformance is mainly accepted as a persistent anomaly in the IPO market.

The findings of this thesis suggest that more research should be conducted now on both short-term returns and long-term performance, since the microeconomic and macroeconomic conditions have transformed significantly through globalization and digitalization. Understanding the differences in current business environment may explain why the new issues experience relatively high initial returns yet the IPOs continue performing well in the aftermarket, too. On the other hand, international studies are needed to demonstrate if the disappearance of the underperformance anomaly is solely an American phenomenon or whether similar results can be found in other stock exchanges. After all, it is remarkable that one of the most studied and widely accepted anomalies in the financial world appears to be disappearing from the IPO market.

7. References

Aggarwal, R. and Rivoli, P. (1990). Fads in the initial public offering market?. *Financial Management*, 19(4), 45-57.

Ahmad-Zaluki, N., Campbell, K. and Goodacre, A. (2007). The long run share price performance of Malaysian initial public offerings (IPOs). *Journal of Business Finance & Accounting*, 34(1-2), 78-110.

Allen, F. and Faulhaber, G. (1989). Signaling by underpricing in the IPO market, *Journal of Financial Economics*, 23(2), 303-323.

Alli, K, Subrahmanyam, V. and Gleason, K. (2010). Short- and long-run performance of initial public offerings in postpartheid South Africa, *Journal of African Business*, 11(1), 1-25.

Alvarez, S. and Gonzáles, V. (2005). Signalling and the long-run performance of Spanish initial public offerings (IPOs), *Journal of Business Finance & Accounting*, 32(1-2), 325-350.

Arosio, R., Paleari, S. and Giudici, G. (2001). The market performance of Italian IPOs in the long-run, Politecnico di Milano Working paper.

Barber, B. and Lyon, J. (1997). Detecting long-run abnormal stock returns: the empirical power and specification of test statistics, *Journal of Financial Economics*, 43(3), 341-372.

Bessler, W. and Thies, S. (2007). The long-run performance of initial public offerings in Germany, *Managerial Finance*, 33(6), 420-441.

Beatty, R. and Ritter, J. (1986). Investment banking, reputation, and the underpricing of initial public offerings, *Journal of Financial Economics*, 15(1-2), 213-232.

Boissin, R. and Sentis, P. (2014). Long-run performance of IPOs and the role of financial analysts: some French evidence, *The European Journal of Finance*, 20(2), 125-149.

Brooks, C. (2008). *Introductory Econometrics for Finance*, New York, NY, Cambridge University Press.

Brown, E. (1999). Long-run performance analysis of a new sample of UK IPOs, University of Edinburgh Working paper.

Brämisch, F., Rottke, N. and Schiereck, D. (2011). IPO underpricing, signaling, and property returns, *Financial Markets and Portfolio Management*, 25(1), 27-51.

Carter, R. and Manaster, S. (1990). Initial public offerings and underwriter reputation, *Journal of Finance*, 45(4), 1045-1067.

Carter, R., Dark, F. and Singh, A. (1998). Underwriter reputation, initial returns, and the long run performance of IPO stocks, *Journal of Finance*, 53(1), 285-311.

Chan, K., Wang, J. and Wei, K. (2004). Underpricing and long-term performance of IPOs in China, *Journal of Corporate Finance*, 10(3), 409-430.

Chemmanur, T. (1993). The pricing of initial public offerings: a dynamic model with information production, *Journal of Finance*, 48(1), 285-304.

Chi, J., Wang, C. and Young, M. (2010). Long-run outperformance of Chinese initial public offerings, *The Chinese Economy*, 43(5), 62-88.

Conrad, J. and Kaul, G. (1993). Long-term market overreaction or biases in computed returns?, *Journal of Finance*, 48(1), 39-64.

Corwin, S. and Schultz, P. (2005). The role of IPO underwriting syndicates: Pricing, information production, and underwriter competition, *Journal of Finance*, 60 (1), 443-486.

Dimson, E. and Marsh, P. (1986). Event study methodologies and the size effect: The case of UK press recommendations, *Journal of Financial Economics*, 17(1), 113-142.

Drake, P. and Vetsuypens, M. (1993). IPO underpricing and insurance against legal liability, *Financial Management*, 22(1), 64–73.

Drobetz, W., Kammermann, M. and Wälchli, U. (2005). Long-run performance of initial public offerings: the evidence for Switzerland, *Schmalenbach Business Review*, 57(3), 253-275.

Espenlaub, S., Tonks, I. and Gregory, A. (1998). Testing the robustness of long-term under-performance of UK initial public offerings, LSE Financial Markets Group Working paper.

Fama, E. (1998). Market efficiency, long-term returns, and behavioral finance, *Journal of Financial Economics*, 49(3), 283-306.

Francis, B., Iftekhar, H., Lothian, J. and Sun, X. (2010). The signaling hypothesis revisited: evidence from foreign IPOs, *Journal of Financial and Quantitative Analysis*, 45(1), 81-106.

Gompers, P. and Lerner, J. (2003). The really long-run performance of initial public offerings: the pre-NASDAQ evidence, *Journal of Finance*, 58(4), 1355 –1392

Gregory, A., Guermat, C. and Al-Shawawreh, F. (2010). UK IPOs: long run returns, behavioural timing and pseudo timing, *Journal of Business Finance & Accounting*, 37(5-6), 612-647.

Grinblatt, M. and Hwang, C. (1989). Signaling and the pricing of new issues, *Journal of Finance*, 44(2), 393-420.

Habib, M. and Ljungqvist, A. (2001). Underpricing and entrepreneurial wealth losses in IPO: theory and evidence, *Review of Financial Studies*, 14(2), 433-458.

Hanley, K. (1993). The underpricing of initial public offerings and the partial adjustment phenomenon, *Journal of Financial Economics*, 34(2), 231-250.

Ibbotson, R. (1975). Price performance of common stock new issues, *Journal of Financial Economics*, 2(3), 235-272.

Ibbotson, R. and Jaffe, J. (1975). "Hot issue" markets, *Journal of Finance*, 30(4), 1027-1042.

Ibbotson, R., Sindelar, J. and Ritter, J. (1994). The market's problems with the pricing of initial public offerings, *Journal of Applied Corporate Finance*, 7(1), 66-74.

Jegadeesh, N., Weinstein, M. and Welch, I. (1993). An empirical investigation of IPO returns and subsequent equity offerings, *Journal of Financial Economics*, 34(2), 153-175.

Jewartowski, T. and Lizińska, J. (2012). Short- and long-term performance of Polish IPOs, *Emerging Markets Finance and Trade*, 48(2), 59-75

Keloharju, M. (1993). The winner's curse, legal liability, and the long-run price performance of initial public offerings in Finland, *Journal of Financial Economics*, 34(2), 251-277.

Kirkulak, B. (2008). The initial and long-run returns of Japanese venture capital-backed and non-venture capital-backed IPOs, *International Journal of Managerial Finance*, 4(2), 112-135.

Kooli, M. and Suret, J. (2004). The aftermarket performance of initial public offerings in Canada, *Journal of Multinational Financial management*, 14(1), 47-66.

Lee, P., Taylor, S. and Walter, T. (1996). Australian IPO pricing in the short and long run, *Journal of Banking & Finance*, 20(7), 1189-1210.

Lerner, H. (1994). Venture capitalists and the decision to go public, *Journal of Financial Economics,* 35(3), 293-316.

Levis, M. (1993). The long-run performance of initial public offerings: The UK experience 1980-1988, *Financial Management*, 22(1), 28-41.

Ljungqvist, A. (1997). Pricing initial public offerings: further evidence from Germany, *European Economic Review*, 41(7), 1309-1320.

Ljungqvist, A. (2005). IPO underpricing. In B. E. Eckbo (Ed.), *Handbook of Corporate Finance* (1st ed., pp. 375-422). Hanover, NH, Elsevier.

Loughran, T., Ritter, J. and Rydqvist, K. (1994). Initial public offerings: international insights, *Pacific-Basin Finance Journal*, 2(2-3), 165-199.

Loughran, T. and Ritter, J. (1995). The new issues puzzle, *Journal of Finance*, 50(1), 23-50.

Loughran, T. and Ritter, J. (2002). Why don't issuers get upset about leaving money on the table in IPOs?, *Review of Financial Studies,* 15(2), 413–443.

Loughran, T. and Ritter, J. (2004). Why has IPO underpricing changed over time?, *Financial Management,* 33(3), 5-37.

Lowry, M., Michaely, R. and Volkova, E. (2017). Initial public offerings: a synthesis of the literature and directions for future research, *Foundations and Trends® in Finance*, 11(3-4), 154-320.

Lowry, M. and Shu, S. (2002). Litigation risk and IPO underpricing, *Journal of Financial Economics*, 65(3), 309-335.

Lyon, J., Barber, B. and Tsai, C. (1999). Improved methods for tests of long-run abnormal stock returns, *Journal of Finance*, 54(1), 165-201.

Michaely, R. and Shaw, W. (1994). The pricing of initial public offerings: tests of adverse-selection and signaling theories, *Review of Financial Studies*, 7(2), 279-319.

Mitchell, M. and Stafford, E. (2000). Managerial decisions and long-term stock price performance, *Journal of Business*, 73(3), 287-329.

Pulliam, S. and Randall S. (2000). Linux deal is focus of IPO-commission probe, *Wall Street Journal*, December 12, C1.

Pulliam, S. and Randall S. (2001). CSFB official set quota for repayment of IPO profits in form of commissions, *Wall Street Journal*, August 10, C1.

Ritter, J. (1984). The “hot issue” market of 1980, *Journal of Business*, 57(2), 215-240.

Ritter, J. (1991). The long run performance of initial public offerings, *Journal of Finance*, 46(1), 3-27.

Ritter, J. and Welch, I. (2002). A review of IPO activity, pricing, and allocations, *Journal of Finance*, 57(4), 1795-1828.

Rock, K. (1986). Why new issues are underpriced, *Journal of Financial Economics*, 15(1-2), 187-212.

Roll, R. (1983). On computing mean returns and the small firm premium. *Journal of Financial Economics*, 12(3), 371-386.

Schultz, P. (2003). Pseudo market timing and the long-run underperformance of IPOs. *Journal of Finance*, 58(2), 483-518.

Siconolfi, M. (1997). Underwriters set aside IPO stock for officials of potential customers, *Wall Street Journal*, November 12, A1.

Su, C., Bangassa, K. and Brookfield, D. (2011). Long-run performance of Chinese initial public offerings: further evidence, *Asia-Pacific Journal of Financial Studies*, 40(2), 285-316.

Su, D. (2004). Adverse-selection versus signaling: evidence from the pricing of Chinese IPOs, *Journal of Economics and Business*, 56(1), 1-19.

Tinic, S. (1988). Anatomy of initial public offerings of common stock, *Journal of Finance*, 43(4), 789-822.

Thomadakis, S., Nounis, C. and Gounopoulos, D. (2012). Long-term performance of Greek IPOs, *European Financial Management*, 18(1), 117–141.

Welch, I. (1989). Seasoned offerings, imitation costs, and the underpricing of initial public offerings, *Journal of Finance*, 44(2), 421-339.

List of appendices

Appendix 1: Abnormal and Cumulative Abnormal Returns for IPOs in 2003 – 2006 61

Appendix 2: Abnormal and Cumulative Abnormal Returns for IPOs in 2007 – 2009 62

Appendix 3: Abnormal and Cumulative Abnormal Returns for IPOs in 2010 – 2016 63

Appendix 4: Equal and Value-weighted BHARs for IPOs in 2003 – 2016 64

Appendix 1: Abnormal and Cumulative Abnormal Returns for IPOs in 2003-2006

This table demonstrates average market-index adjusted returns (AR_t) and cumulative average market-adjusted returns (CAR_t) with associated t-statistic for the first 36 months after running an IPO, excluding the initial first-day returns. The number of trading companies begins at less than 481 as some firms have a delay of one month after the IPO before becoming listed. The t-statistic for the average market-adjusted returns is computed for each month as $AR_t \cdot \sqrt{n_t}/sd_t$, where sd_t is the cross-sectional standard deviation of the adjusted returns in month t. The t-statistic for the cumulative average market-adjusted returns is computed for each month as $CAR_{1,t} \cdot \sqrt{n_t}/csd_t$, where csd_t is computed as $csd_t = [t \cdot var + 2 \cdot (t-1) \cdot cov]^{1/2}$, where var is the 36-month cross-sectional variance, and cov is the first-order autocovariance of the AR_t series.

Month of seasoning	Number of IPOs trading	AR_t	*t*-statistic	CAR_t	*t*-statistic
1	478	1.2 %	2.034	1.2 %	1.564
2	481	1.5 %	2.145	2.7 %	2.546
3	481	0.8 %	1.108	3.5 %	2.673
4	481	0.0 %	0.034	3.5 %	2.329
5	481	-0.1 %	-0.191	3.4 %	2.013
6	480	-0.9 %	-1.379	2.5 %	1.335
7	479	-0.1 %	-0.107	2.4 %	1.199
8	478	0.6 %	0.988	3.0 %	1.419
9	478	1.2 %	1.776	4.2 %	1.863
10	478	0.1 %	0.177	4.3 %	1.813
11	476	1.2 %	1.998	5.5 %	2.200
12	475	0.4 %	0.545	5.9 %	2.242
13	474	0.9 %	1.590	6.8 %	2.495
14	472	-0.3 %	-0.557	6.5 %	2.278
15	470	-0.6 %	-1.021	5.8 %	1.977
16	467	-0.4 %	-0.586	5.5 %	1.787
17	462	-0.6 %	-0.898	4.9 %	1.539
18	459	-0.5 %	-0.644	4.4 %	1.347
19	457	1.0 %	1.111	5.5 %	1.620
20	454	-0.7 %	-1.033	4.8 %	1.379
21	453	-1.7 %	-2.428	3.0 %	0.857
22	450	0.2 %	0.233	3.2 %	0.884
23	442	-0.7 %	-0.832	2.5 %	0.668
24	439	1.4 %	1.424	3.9 %	1.017
25	436	-1.4 %	-1.987	2.6 %	0.647
26	432	1.0 %	1.273	3.5 %	0.872
27	431	-0.6 %	-0.651	2.9 %	0.711
28	428	-0.6 %	-0.648	2.3 %	0.555
29	423	0.4 %	0.454	2.7 %	0.630
30	421	-0.3 %	-0.430	2.4 %	0.542
31	416	-0.3 %	-0.358	2.1 %	0.463
32	413	-0.5 %	-0.626	1.6 %	0.346
33	406	0.0 %	0.000	1.6 %	0.338
34	403	1.1 %	1.151	2.7 %	0.555
35	400	-1.5 %	-1.552	1.1 %	0.233
36	395	1.9 %	1.063	3.1 %	0.614

Appendix 2: Abnormal and Cumulative Abnormal Returns for IPOs in 2007-2009

This table demonstrates average market-index adjusted returns (AR_t) and cumulative average market-adjusted returns (CAR_t) with associated t-statistic for the first 36 months after running an IPO, excluding the initial first-day returns. The number of trading companies begins at less than 195 as some firms have a delay of one month after the IPO before becoming listed. The t-statistic for the average market-adjusted returns is computed for each month as $AR_t \cdot \sqrt{n_t}/sd_t$, where sd_t is the cross-sectional standard deviation of the adjusted returns in month t. The t-statistic for the cumulative average market-adjusted returns is computed for each month as $CAR_{1,t} \cdot \sqrt{n_t}/csd_t$, where csd_t is computed as $csd_t = [t \cdot var + 2 \cdot (t-1) \cdot cov]^{1/2}$, where var is the 36-month cross-sectional variance, and cov is the first-order autocovariance of the AR_t series.

Month of seasoning	Number of IPOs trading	AR_t	*t*-statistic	CAR_t	*t*-statistic
1	194	-1.1 %	-1.211	-1.1 %	-0.772
2	194	-1.3 %	-1.085	-2.4 %	-1.207
3	195	1.7 %	1.813	-0.7 %	-0.295
4	195	-0.3 %	-0.248	-1.0 %	-0.352
5	195	0.2 %	0.147	-0.8 %	-0.257
6	195	-4.3 %	-4.434	-5.1 %	-1.496
7	195	0.0 %	-0.004	-5.1 %	-1.387
8	195	-0.6 %	-0.473	-5.7 %	-1.445
9	194	-0.3 %	-0.227	-6.0 %	-1.434
10	194	-2.2 %	-1.643	-8.1 %	-1.848
11	194	-0.5 %	-0.370	-8.7 %	-1.874
12	194	1.0 %	0.714	-7.7 %	-1.586
13	189	0.8 %	0.531	-6.9 %	-1.348
14	189	1.9 %	1.476	-4.9 %	-0.936
15	188	-0.6 %	-0.478	-5.5 %	-1.011
16	188	0.5 %	0.289	-5.0 %	-0.889
17	186	0.1 %	0.047	-5.0 %	-0.846
18	186	2.9 %	1.984	-2.1 %	-0.345
19	186	2.1 %	1.338	0.0 %	0.007
20	185	2.7 %	1.114	2.7 %	0.424
21	185	-0.4 %	-0.292	2.3 %	0.358
22	185	3.2 %	1.922	5.6 %	0.835
23	185	4.9 %	2.851	10.5 %	1.540
24	183	1.7 %	1.310	12.3 %	1.747
25	180	6.0 %	2.350	18.3 %	2.526
26	178	3.3 %	2.126	21.5 %	2.904
27	176	4.6 %	3.097	26.2 %	3.444
28	175	1.2 %	0.574	27.4 %	3.531
29	174	1.5 %	0.859	28.9 %	3.656
30	173	0.7 %	0.498	29.6 %	3.665
31	170	0.7 %	0.691	30.3 %	3.657
32	169	2.2 %	1.510	32.5 %	3.853
33	167	-0.6 %	-0.567	31.9 %	3.703
34	167	-0.1 %	-0.090	31.8 %	3.636
35	166	0.5 %	0.522	32.3 %	3.631
36	165	1.5 %	1.613	33.8 %	3.731

Appendix 3: Abnormal and Cumulative Abnormal Returns for IPOs in 2010-2016

This table demonstrates average market-index adjusted returns (AR_t) and cumulative average market-adjusted returns (CAR_t) with associated t-statistic for the first 36 months after running an IPO, excluding the initial first-day returns. The number of trading companies begins at less than 785 as some firms have a delay of one or two months after the IPO before becoming listed. The t-statistic for the average market-adjusted returns is computed for each month as $AR_t \cdot \sqrt{n_t}/sd_t$, where $\mathrm{sd_t}$ is the cross-sectional standard deviation of the adjusted returns in month t. The t-statistic for the cumulative average market-adjusted returns is computed for each month as $CAR_{1,t} \cdot \sqrt{n_t}/csd_t$, where $\mathrm{csd_t}$ is computed as $csd_t = [t \cdot var + 2 \cdot (t-1) \cdot cov]^{1/2}$, where var is the 36-month cross-sectional variance, and cov is the first-order autocovariance of the AR_t series.

Month of seasoning	Number of IPOs trading	AR_t	*t*-statistic	CAR_t	*t*-statistic
1	776	3.2 %	4.739	3.2 %	5.016
2	784	1.4 %	2.085	4.6 %	5.116
3	785	0.3 %	0.475	4.9 %	4.476
4	783	-0.7 %	-1.166	4.2 %	3.291
5	783	0.1 %	0.166	4.3 %	3.023
6	783	-2.1 %	-3.415	2.2 %	1.413
7	782	-1.4 %	-2.560	0.8 %	0.476
8	781	-0.2 %	-0.338	0.6 %	0.339
9	781	0.0 %	0.082	0.7 %	0.345
10	779	-1.0 %	-1.882	-0.4 %	-0.186
11	778	1.0 %	1.639	0.6 %	0.283
12	773	0.0 %	-0.072	0.6 %	0.251
13	773	0.1 %	0.147	0.6 %	0.281
14	772	-0.6 %	-1.010	0.1 %	0.024
15	770	0.4 %	0.525	0.4 %	0.177
16	768	0.0 %	0.067	0.5 %	0.187
17	767	0.2 %	0.332	0.7 %	0.269
18	762	-0.9 %	-1.261	-0.2 %	-0.070
19	756	-0.1 %	-0.197	-0.3 %	-0.107
20	752	0.1 %	0.207	-0.2 %	-0.062
21	751	0.8 %	1.359	0.6 %	0.218
22	745	0.5 %	0.793	1.1 %	0.370
23	742	-0.7 %	-1.049	0.4 %	0.134
24	741	-0.8 %	-1.132	-0.3 %	-0.110
25	737	-0.5 %	-0.805	-0.9 %	-0.266
26	730	1.1 %	1.580	0.2 %	0.058
27	723	-0.4 %	-0.674	-0.2 %	-0.070
28	712	0.6 %	0.984	0.4 %	0.107
29	705	-0.6 %	-0.953	-0.2 %	-0.054
30	700	-1.5 %	-2.466	-1.7 %	-0.461
31	695	-0.7 %	-1.390	-2.4 %	-0.649
32	689	0.9 %	1.233	-1.5 %	-0.394
33	686	0.3 %	0.374	-1.2 %	-0.314
34	677	2.2 %	1.625	1.0 %	0.261
35	672	1.3 %	1.927	2.3 %	0.583
36	668	-1.6 %	-2.484	0.7 %	0.183

Appendix 4: Equal and Value-weighted BHARs for IPOs in 2003-2016

This table demonstrates equally weighted market-index adjusted buy-and-hold returns (EW $BHAR_t$) and value-weighted market-index adjusted buy-and-hold returns (EW $BHAR_t$) with associated t-statistic for the first 36 months after running an IPO, excluding the initial first-day returns. The number of trading companies begins at less than 1461 as some firms have a delay of one or two months after the IPO before becoming listed. The *t*-statistic for the market-adjusted buy-and-hold returns is computed for each month as $t_{BHAR} = \sqrt{n}\left(S + \frac{1}{3}\hat{\gamma}\cdot S^2 + \frac{1}{6n}\hat{\gamma}\right)$, where $S = \frac{\overline{BHAR}_t}{\sigma(BHAR_t)}$ and $\hat{\gamma} = \frac{\sum_{i=1}^{n}(BHAR_{i,t}-\overline{BHAR}_t)^3}{n\cdot\sigma(BHAR_t)^3}$. $\hat{\gamma}$ is an estimate of the coefficient of skewness.

Month of seasoning	Number of IPOs trading	EW $BHAR_t$	*t*-statistic	VW $BHAR_t$	*t*-statistic
1	1448	2.0 %	4.879	1.2 %	2.913
2	1459	3.2 %	5.209	3.2 %	5.306
3	1461	4.0 %	5.261	3.3 %	4.313
4	1459	3.6 %	4.057	2.0 %	2.201
5	1459	3.2 %	3.343	0.2 %	0.200
6	1458	0.8 %	0.772	-2.0 %	-1.843
7	1456	0.1 %	0.087	-2.1 %	-1.784
8	1454	0.8 %	0.653	-1.2 %	-0.861
9	1453	1.3 %	0.962	-1.3 %	-0.876
10	1451	0.3 %	0.252	-2.3 %	-1.562
11	1448	1.6 %	1.081	-0.4 %	-0.245
12	1442	2.1 %	1.318	-1.0 %	-0.561
13	1436	2.7 %	1.557	-0.3 %	-0.131
14	1433	1.6 %	0.918	-0.8 %	-0.399
15	1428	1.6 %	0.838	-0.3 %	-0.125
16	1423	1.7 %	0.836	-0.3 %	-0.098
17	1415	2.6 %	1.138	0.6 %	0.270
18	1407	1.8 %	0.836	-0.5 %	-0.209
19	1399	2.2 %	0.964	0.2 %	0.123
20	1391	2.7 %	1.156	0.5 %	0.213
21	1389	2.1 %	0.896	0.3 %	0.139
22	1380	2.5 %	1.029	0.8 %	0.344
23	1369	2.3 %	0.927	1.1 %	0.471
24	1363	1.1 %	0.480	-0.2 %	-0.083
25	1353	0.6 %	0.241	-0.2 %	-0.065
26	1340	1.6 %	0.630	0.5 %	0.203
27	1330	2.7 %	0.959	0.9 %	0.343
28	1315	0.9 %	0.367	0.6 %	0.225
29	1302	1.7 %	0.623	0.7 %	0.265
30	1294	0.6 %	0.226	-0.7 %	-0.212
31	1281	1.3 %	0.419	0.3 %	0.118
32	1271	2.3 %	0.725	1.3 %	0.421
33	1259	1.4 %	0.443	1.4 %	0.459
34	1247	1.1 %	0.372	1.8 %	0.569
35	1238	1.4 %	0.454	1.3 %	0.418
36	1228	1.1 %	0.348	1.4 %	0.465